Gamma Ray Bursts and Cosmology with Constellation X

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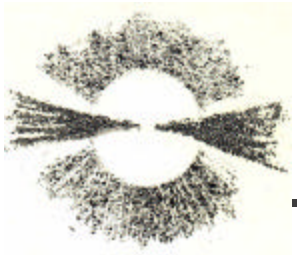
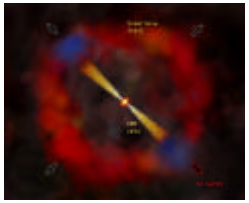
November 21st 2003

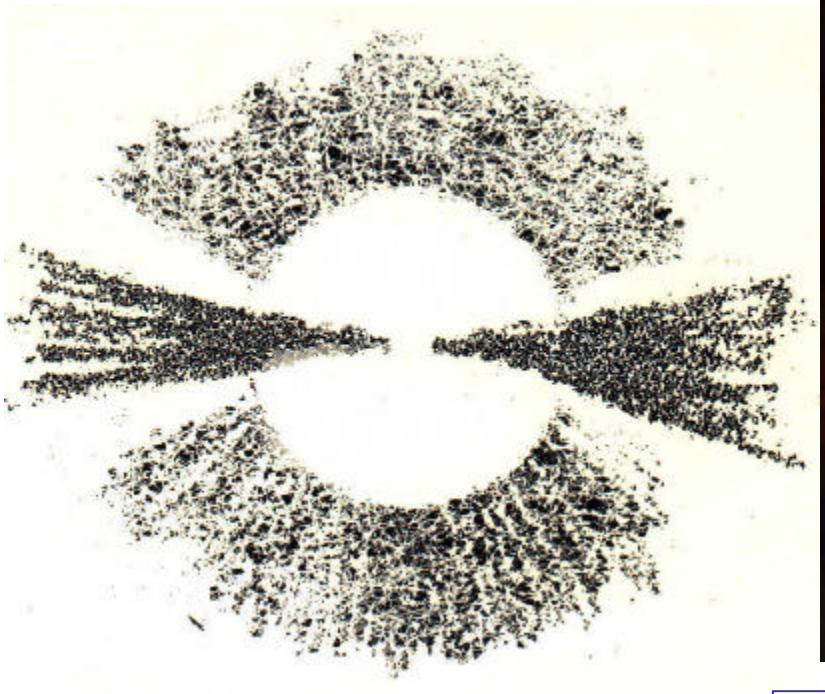


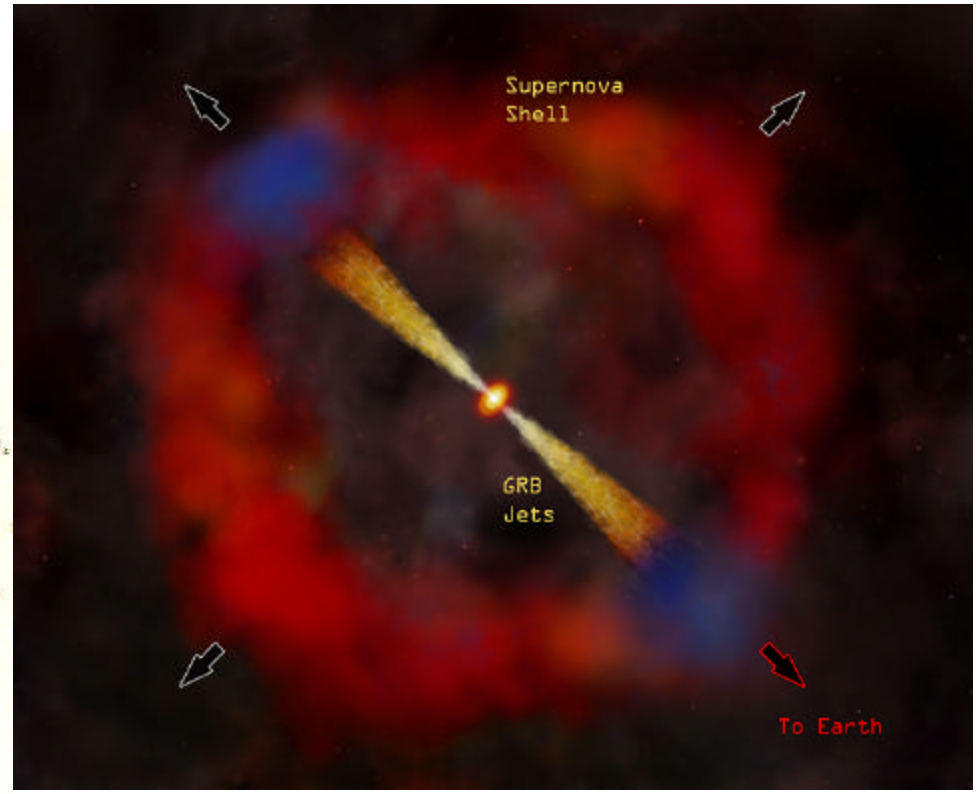
GRB a general introduction



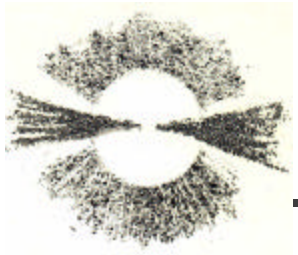
An artistic connection?

e^+e^- 1970's

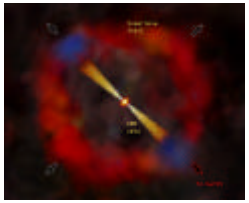




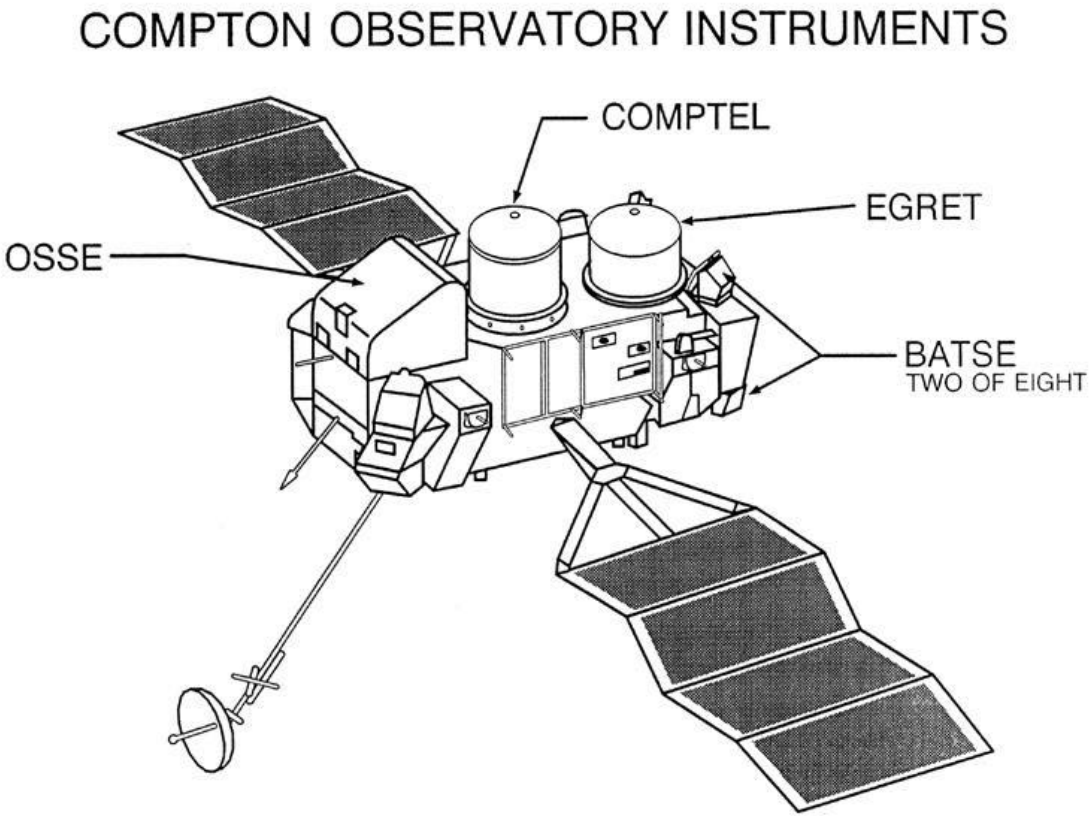
GRB 020813 (credits to CXO/NASA)

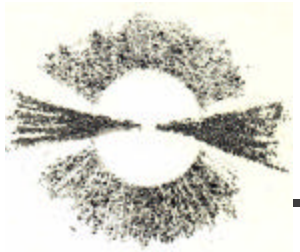


The “gamma” era

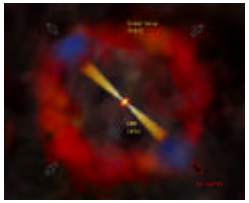


- Distribution of sources
- Cosmological or Galactic?
- No host problem
- NS binary?

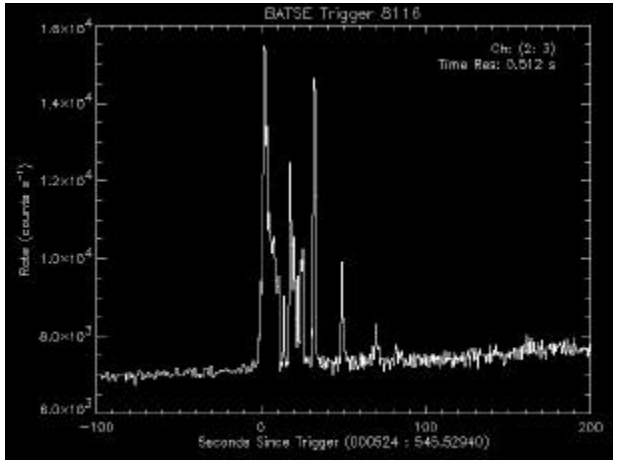




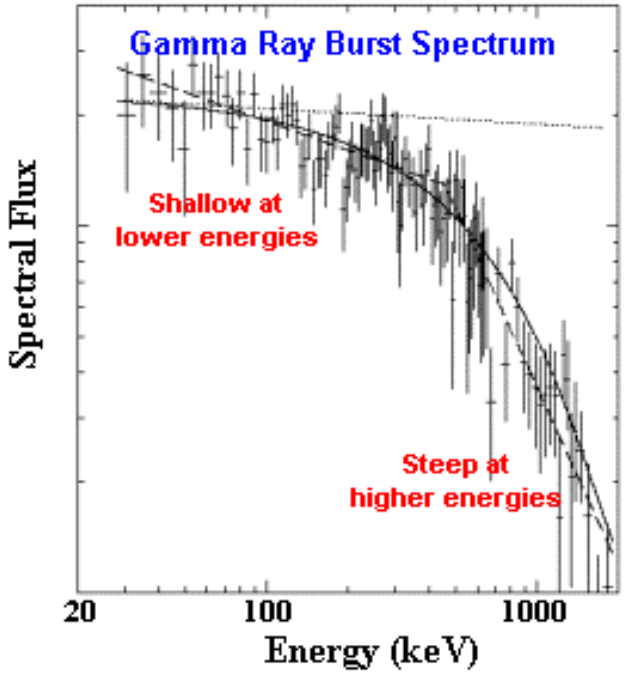
Gamma-Ray Bursts

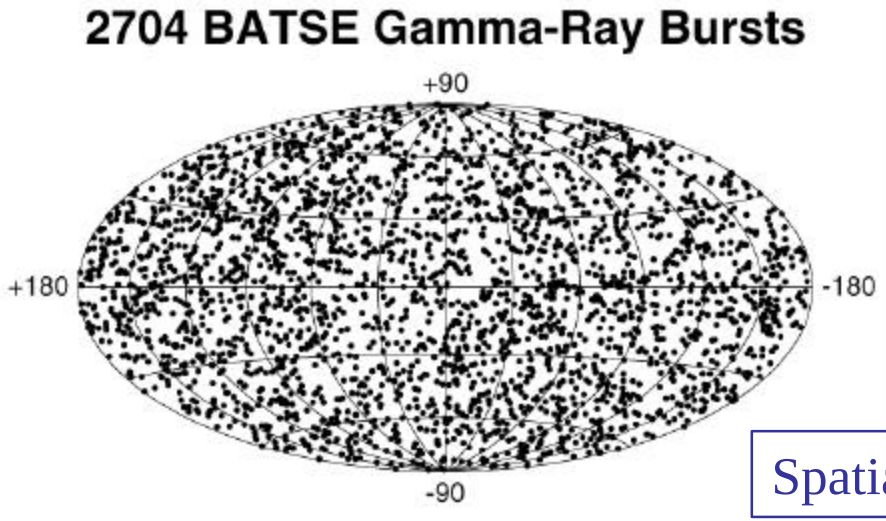


Temporal behaviour



Spectral shape





Spatial distribution

GRB: where are they?

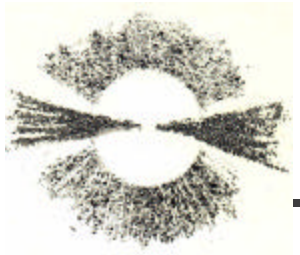
The great debate (1995)

Fluence:10^{-7} erg cm^{-2} s^{-1}
Distance: 1 Gpc
Energy:10^{51} erg

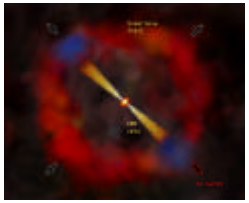
Distance: 100 kpc
Energy: 10^{43} erg

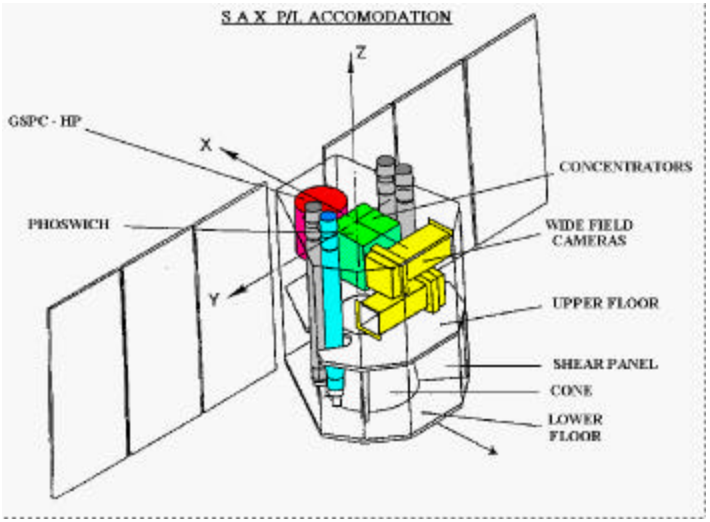
Cosmological - Galactic?

Need a new type of observation!

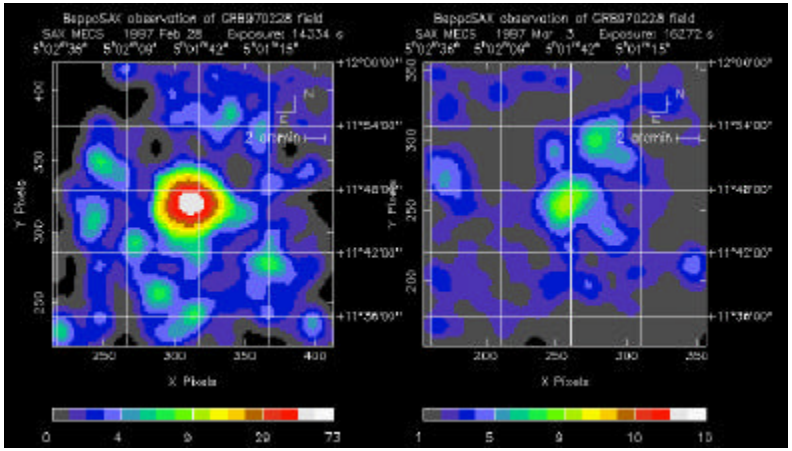


The Afterglow

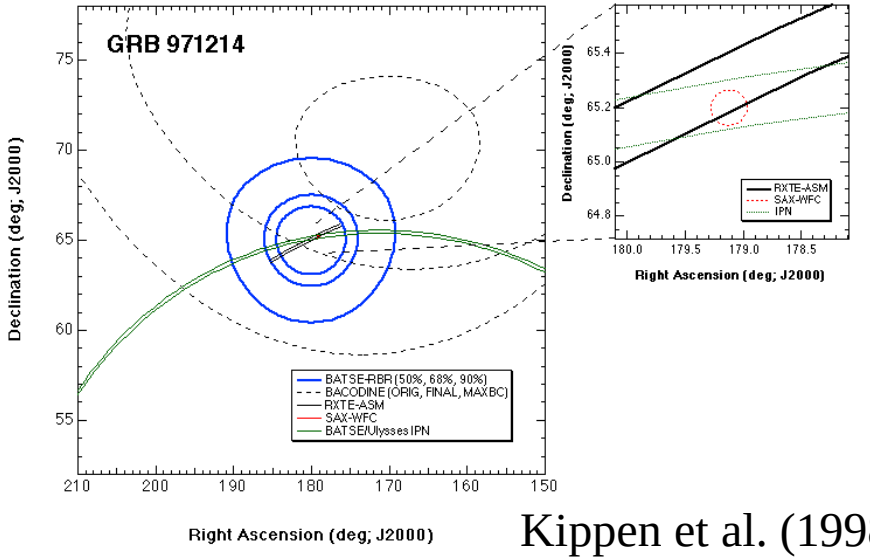




- Good Angular resolution (< arcmin)
- Observation of the X-Afterglow

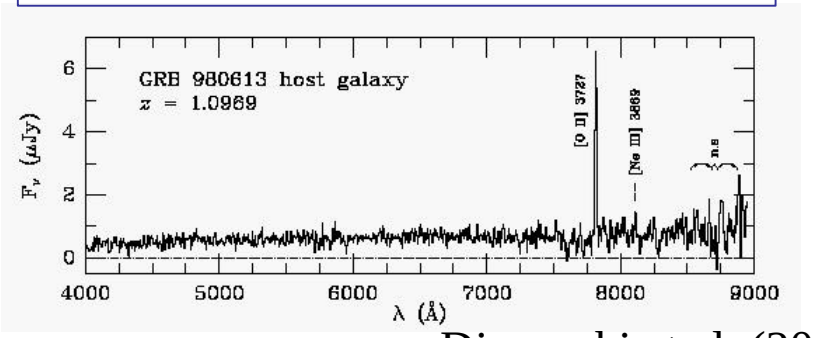


Costa et al. (1997)

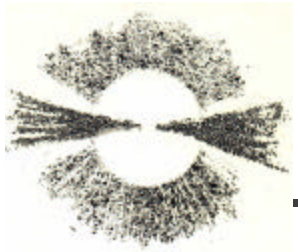


Kippen et al. (1998)

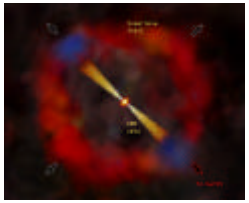
- Optical Afterglow (HST, Keck)
- Direct observation of the host galaxies
- Distance determination



Djorgoski et al. (2000)

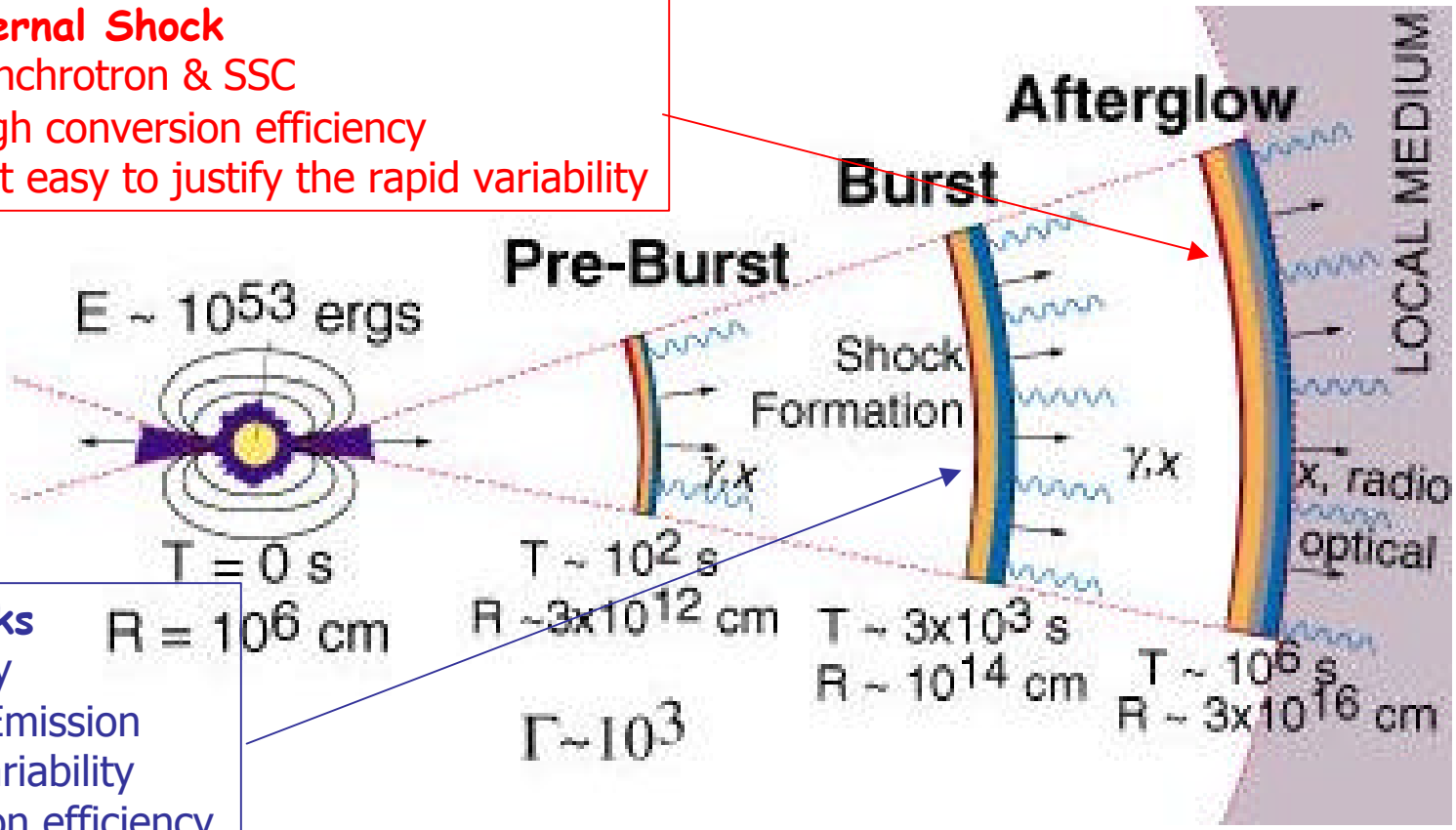


The Fireball model

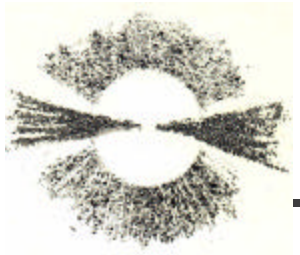


- Relativistic motion of the emitting region
- Shock mechanism converts the kinetic energy of the shells into radiation.
- Baryon Loading problem

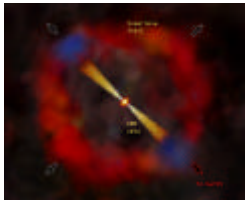
External Shock
- Synchrotron & SSC
- High conversion efficiency
- Not easy to justify the rapid variability



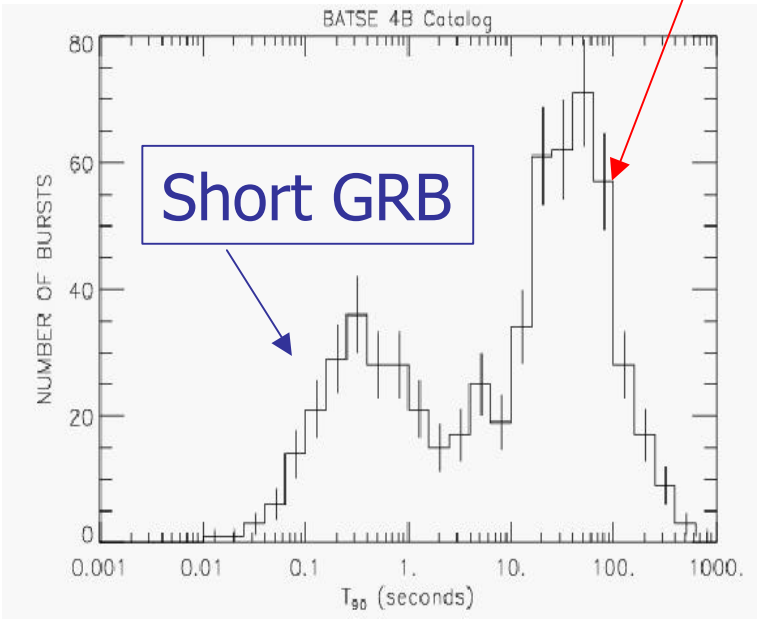
Internal Shocks
- Source activity
- Synchrotron Emission
- Rapid time Variability
- Low conversion efficiency



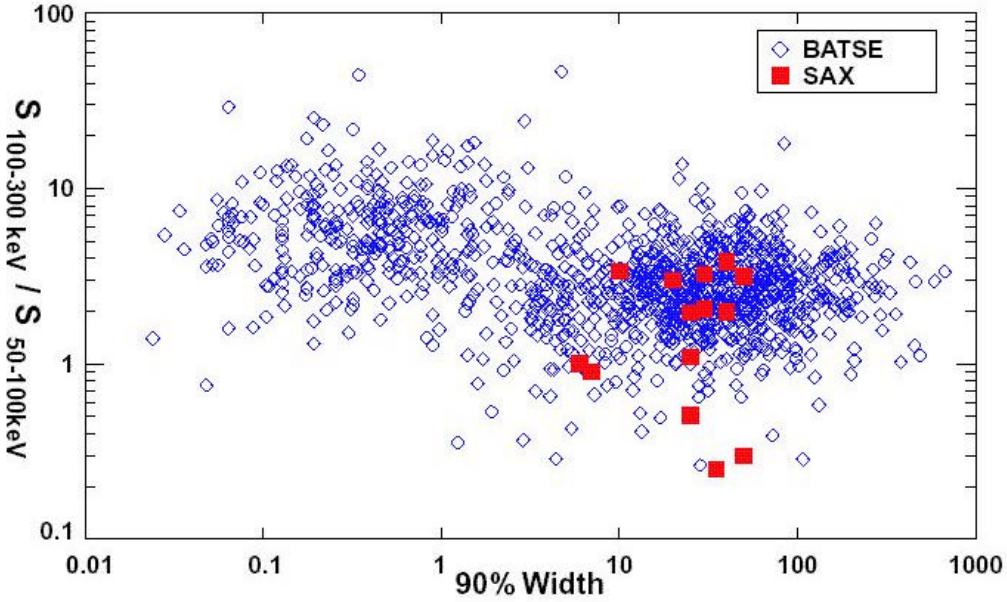
GRB Progenitors

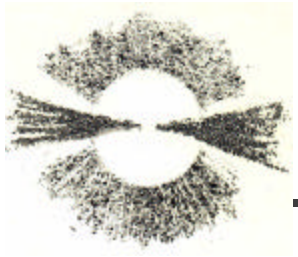


Long GRB

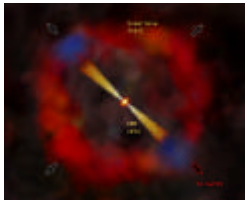


Short GRB

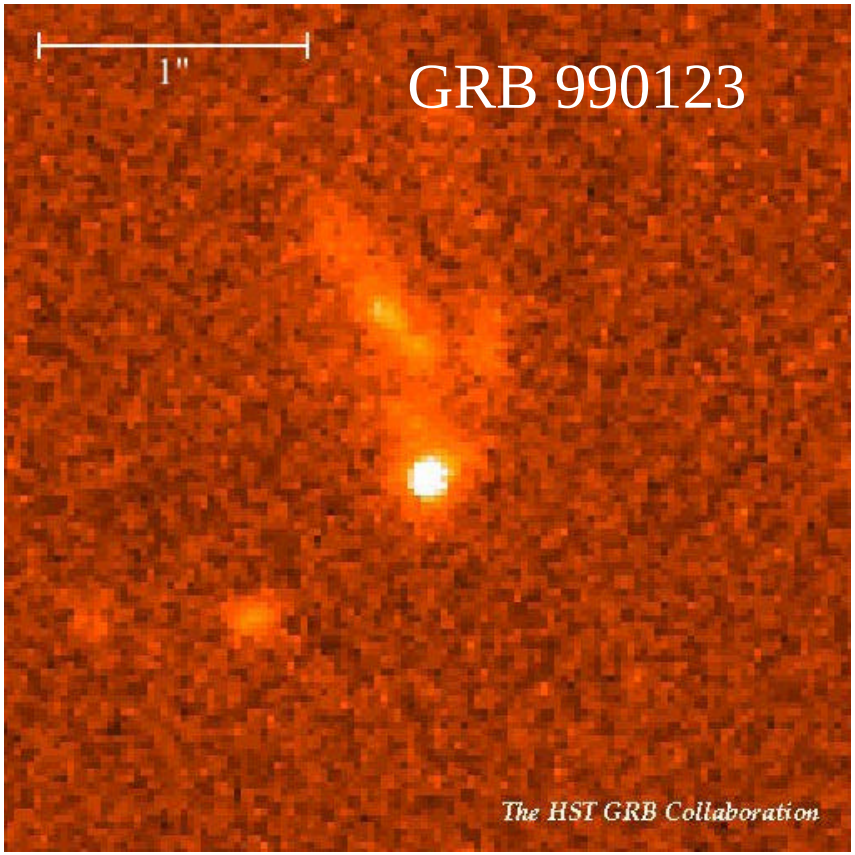


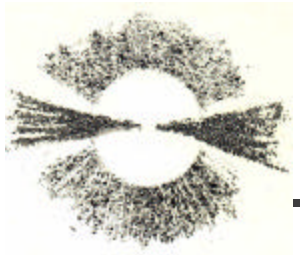


The "afterglow era"

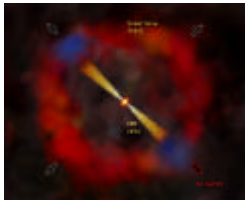


- Detection of Host Galaxies
- GRB beaming and energetics
- SN connection
- X-ray lines

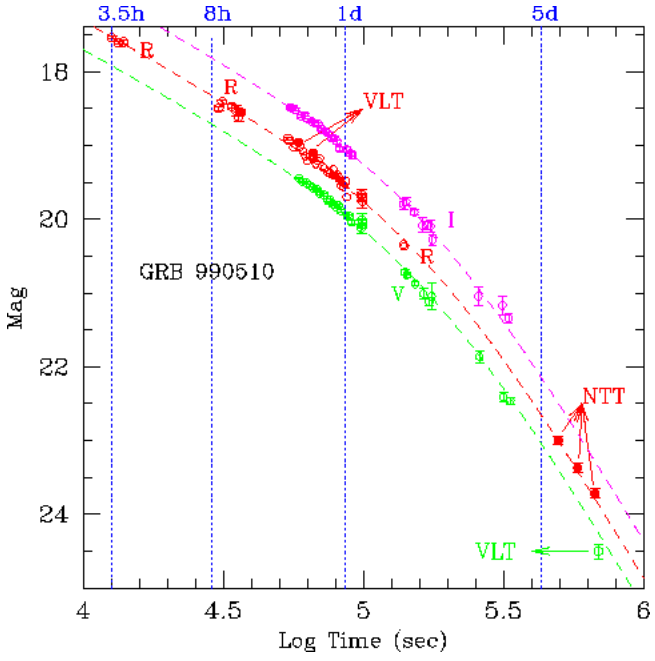




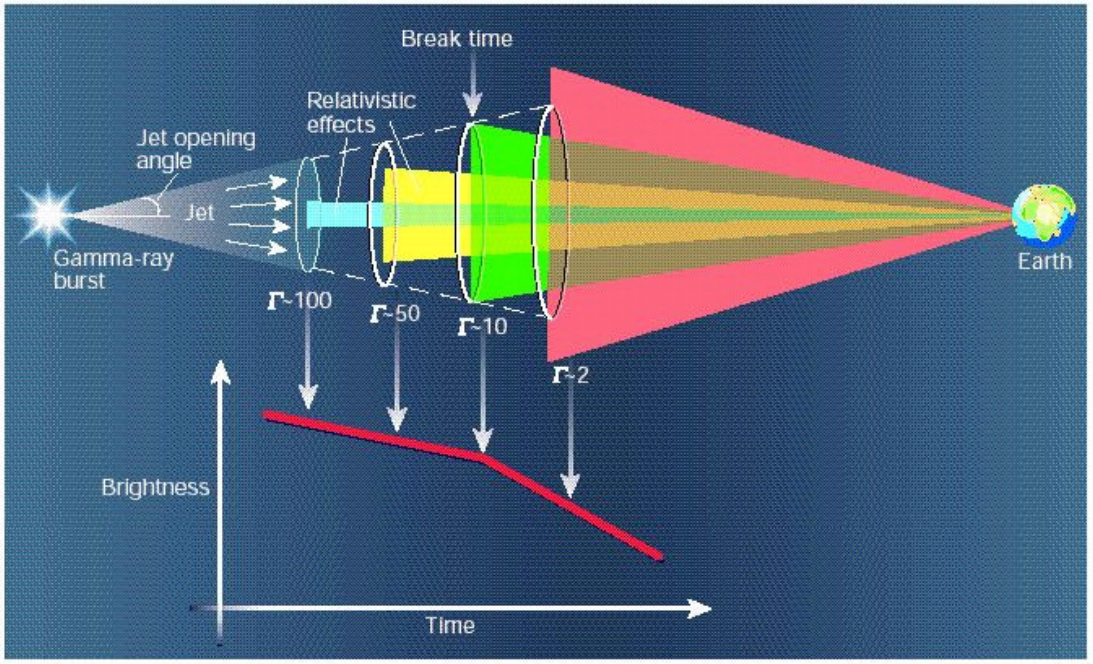
Jet Opening Angle



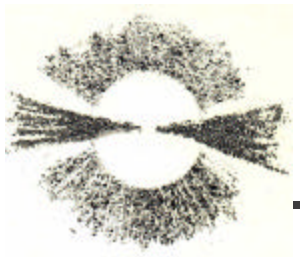
Harrison et al (1999)



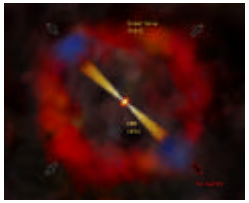
Achromatic Break

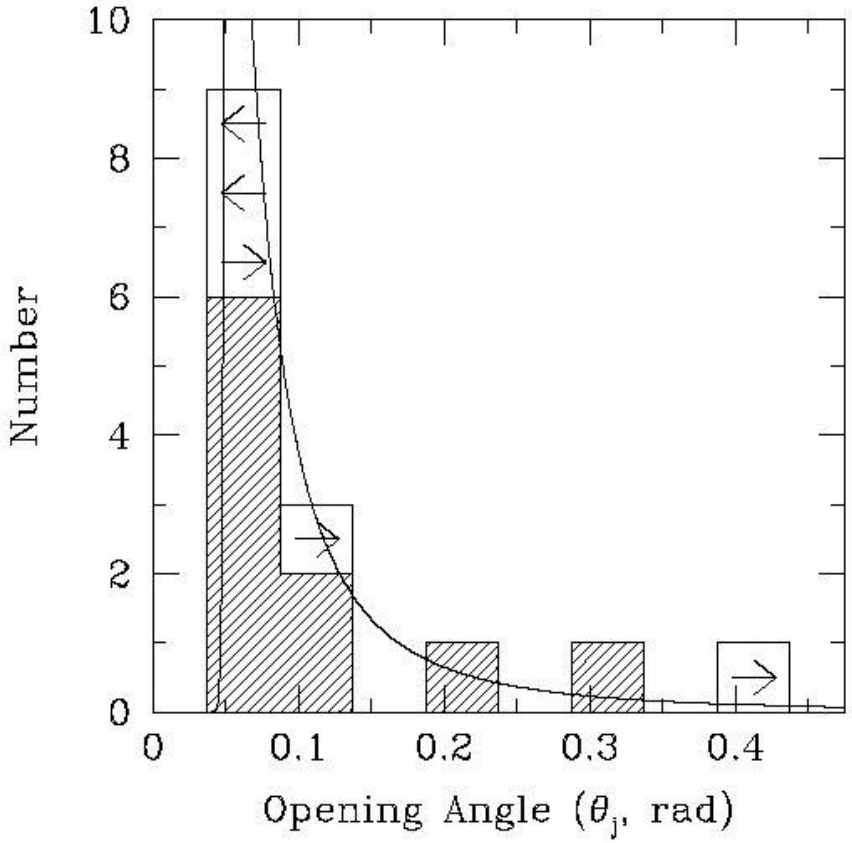


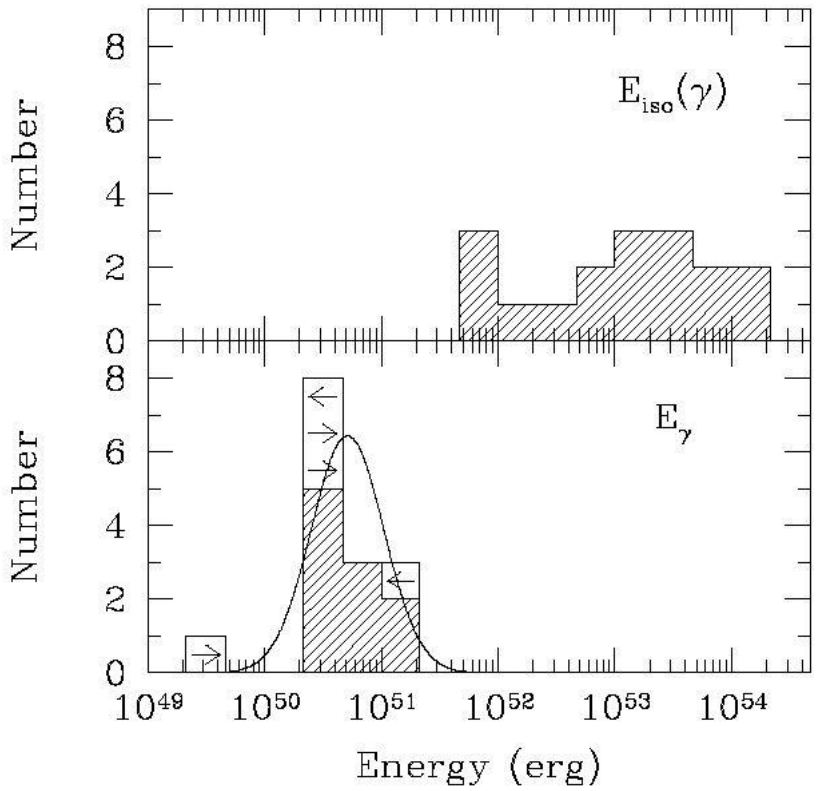
Woosley (2001)



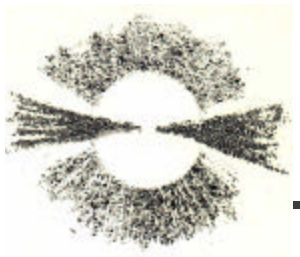
Jet and Energy Requirements



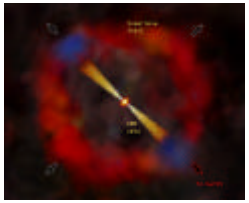


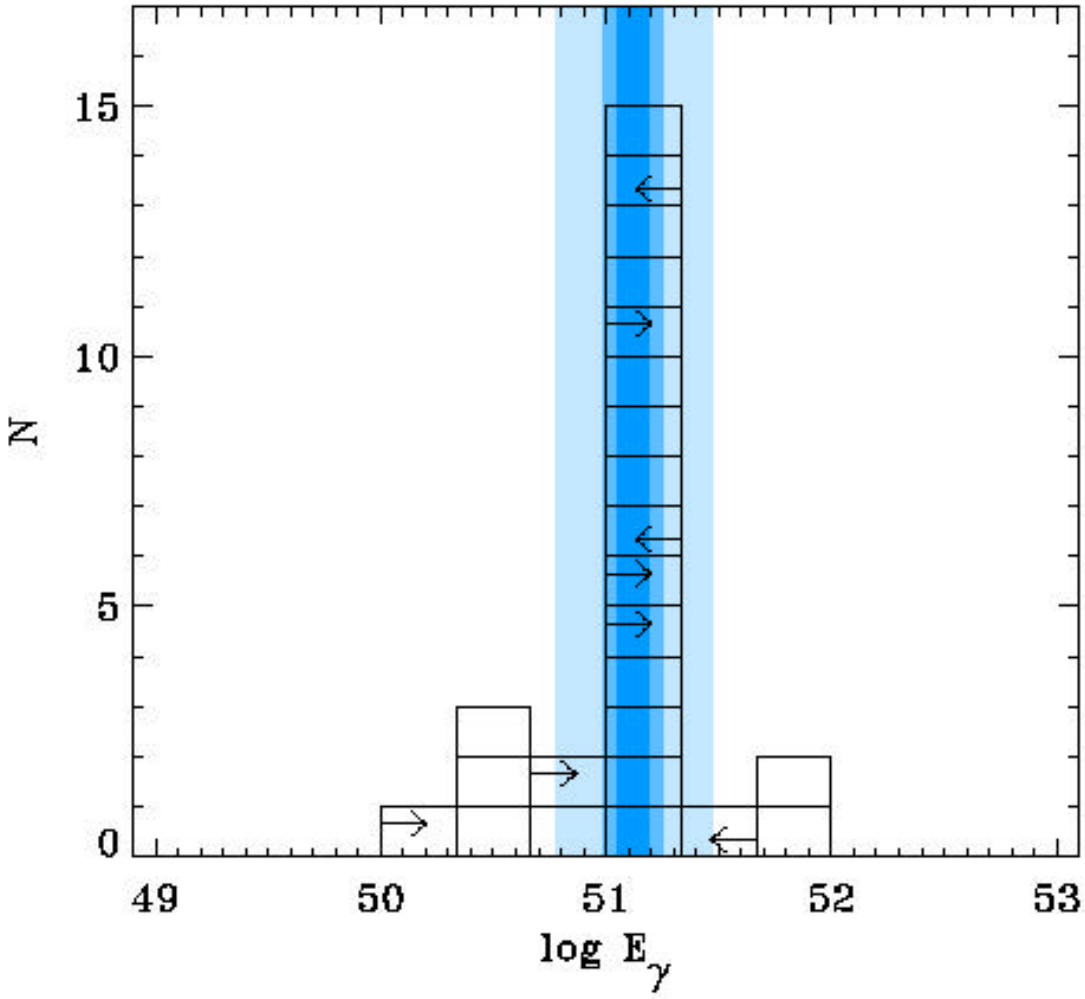


Frail et al. (2001)

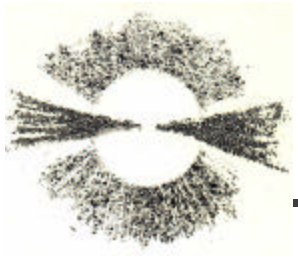


Jet and Energy Requirements

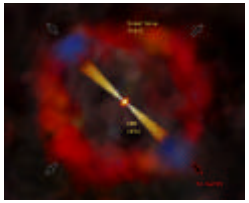




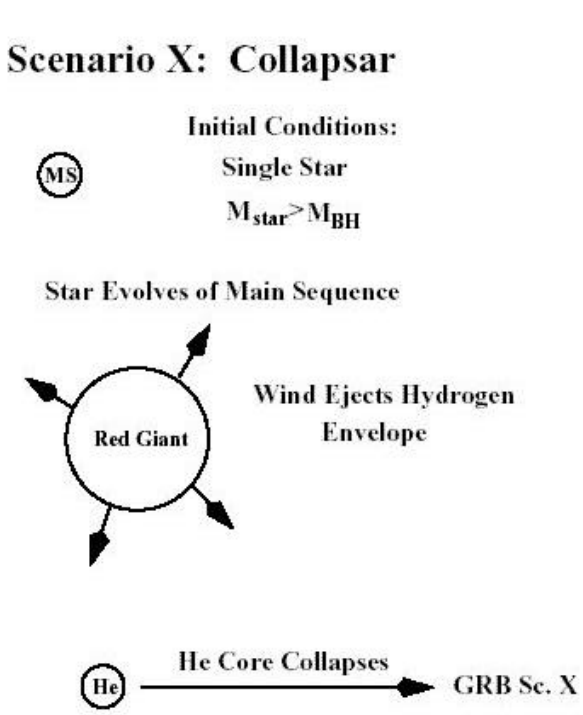
Bloom et al. (2003)

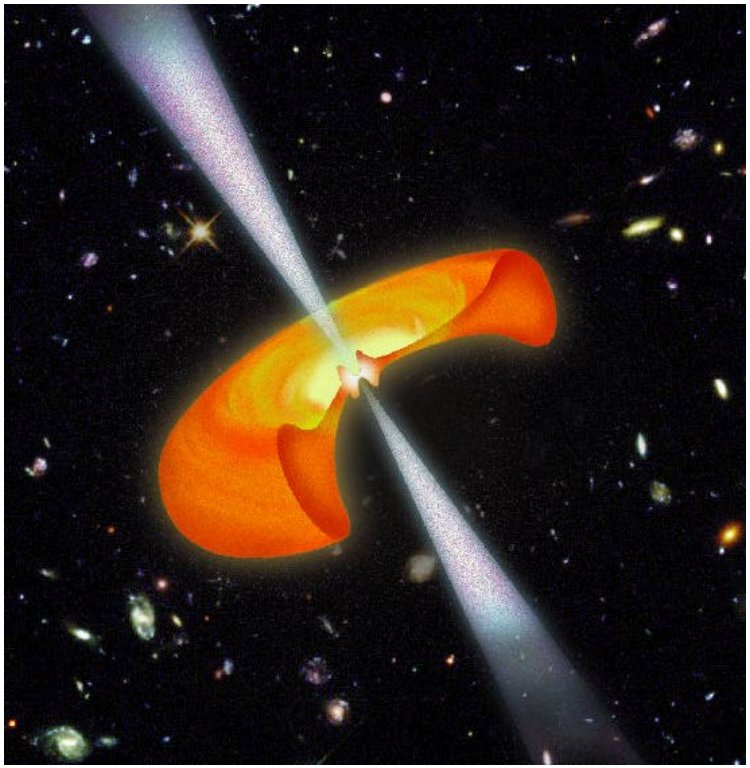


Collapsar model



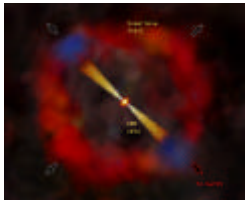
Woosley (1993)

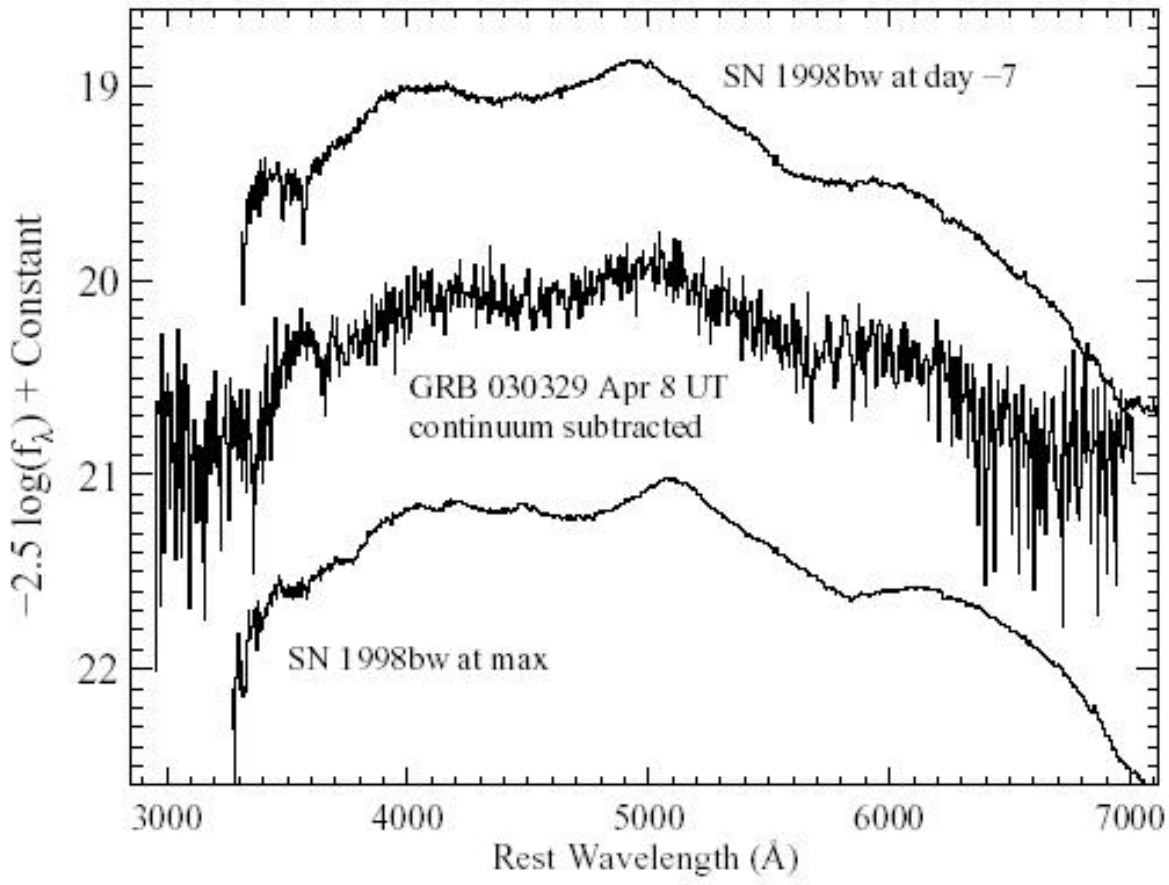




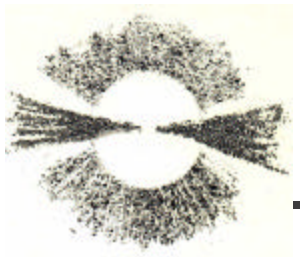
- Very massive star that collapses in a rapidly spinning BH.
- Identification with SN explosion.

GRB 030329: the "smoking gun"?

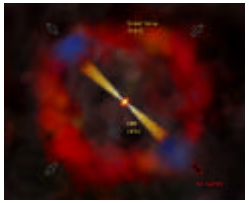




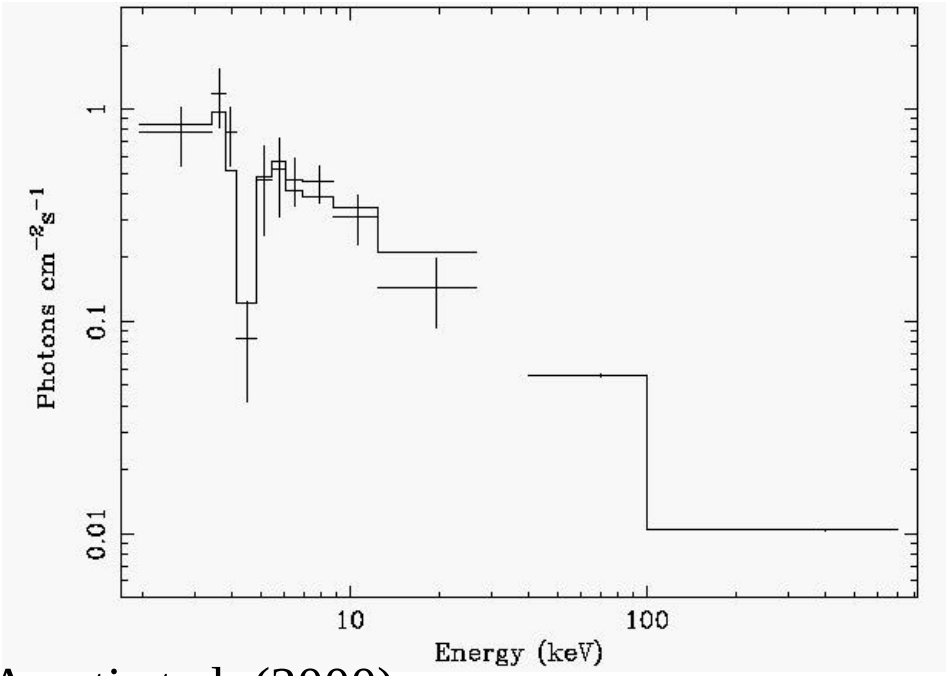
(Matheson et al. 2003)



X-ray Lines

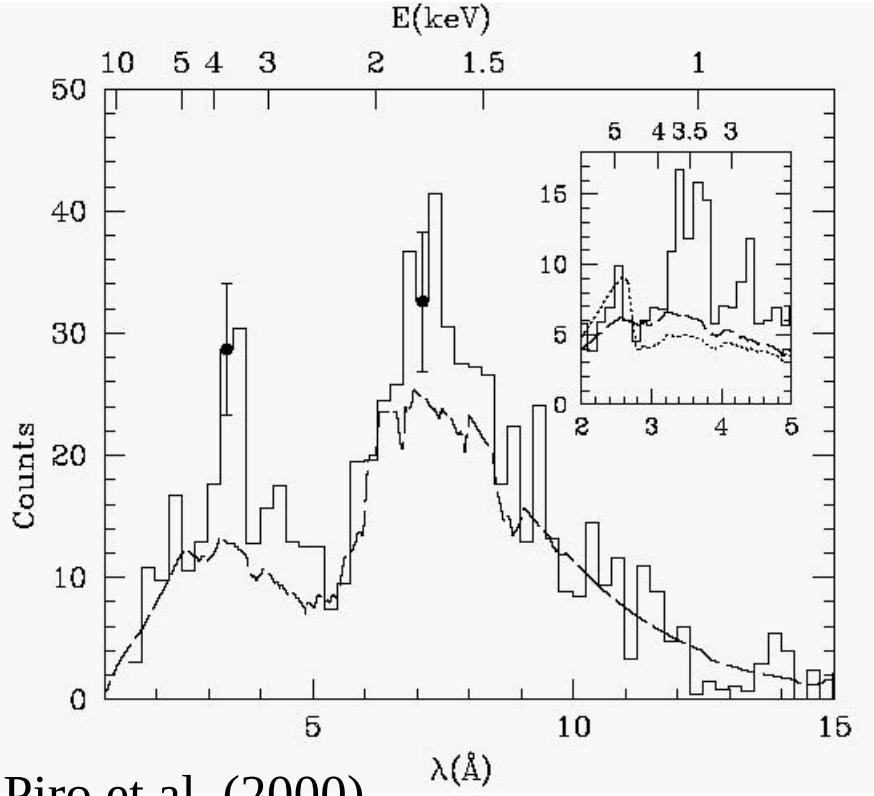


GRB 990705



Amati et al. (2000)

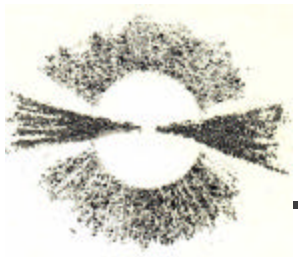
Emission Lines



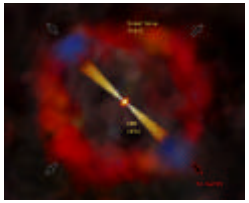
Piro et al. (2000)

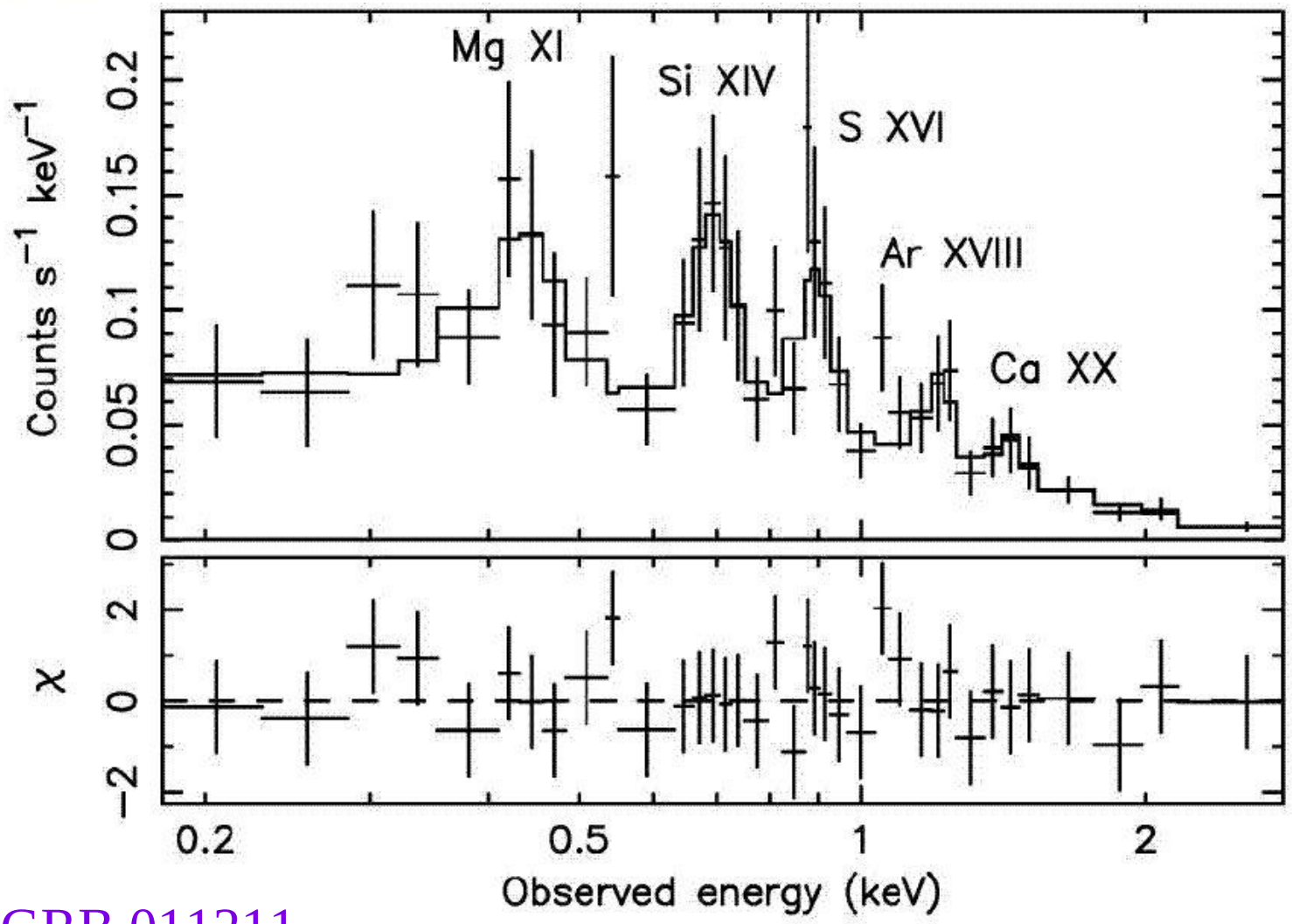
Transient Absorbtion Line

GRB 991216



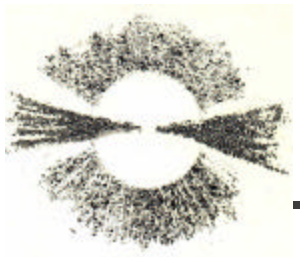
X-ray Lines



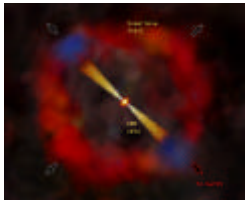


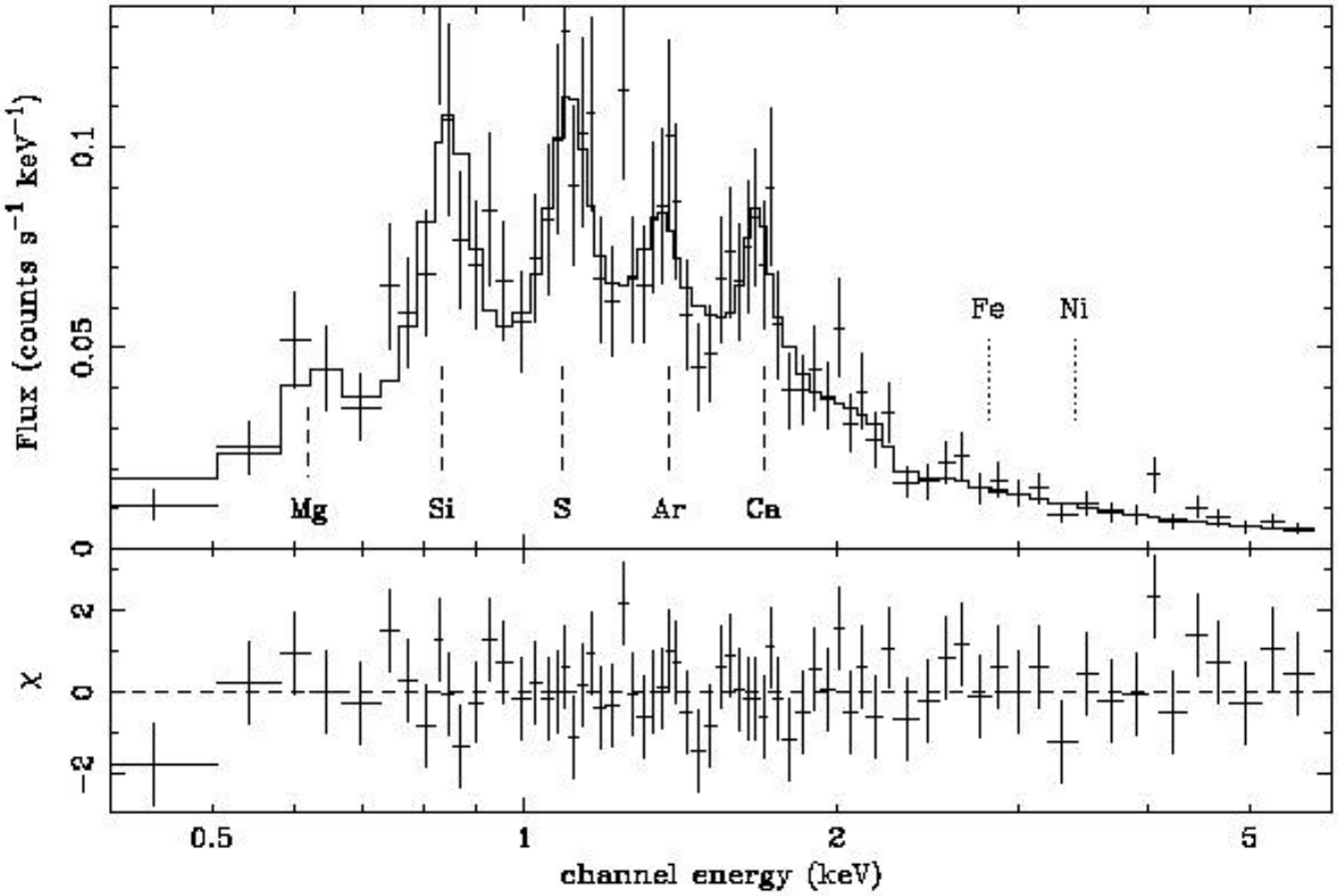
GRB 011211

Reeves et al. (2002)



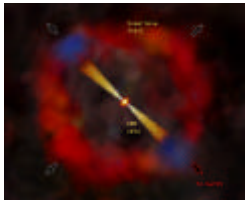
X-ray Lines





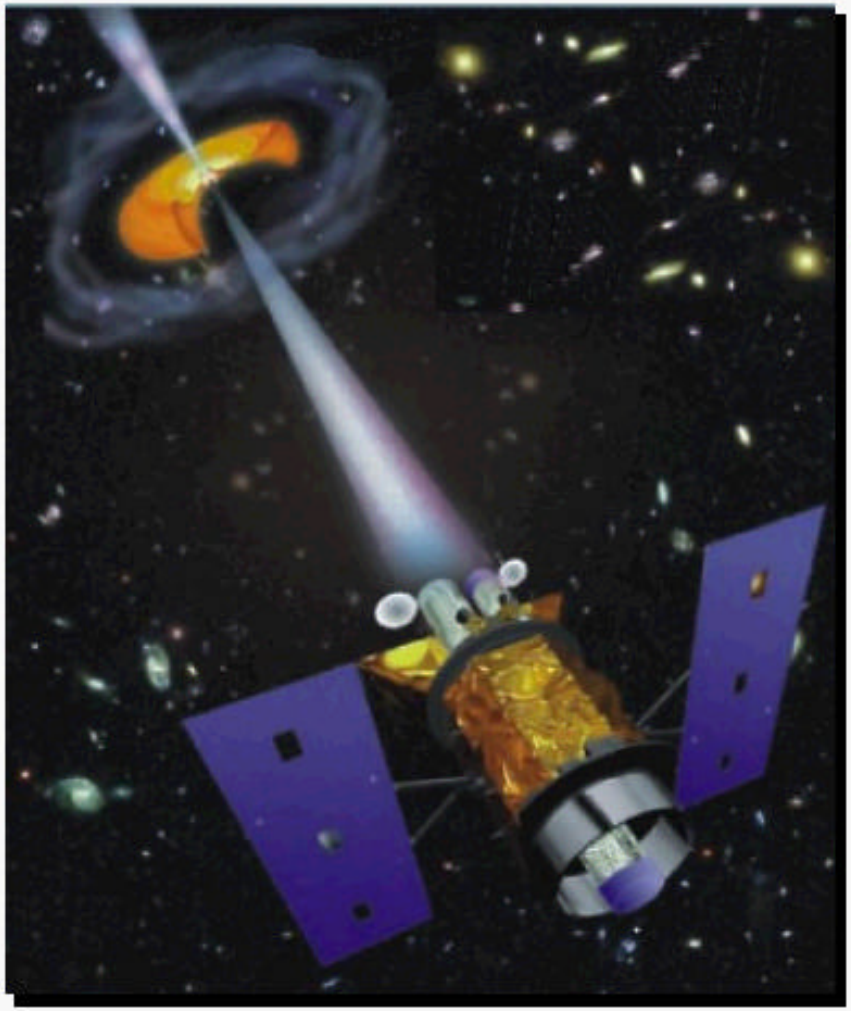
GRB 030227

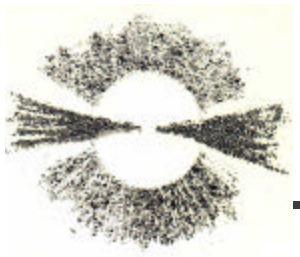
Watson et al. (2003)



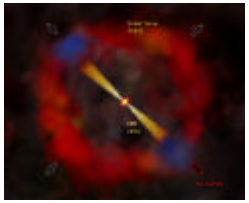
A "Cosmological" era?

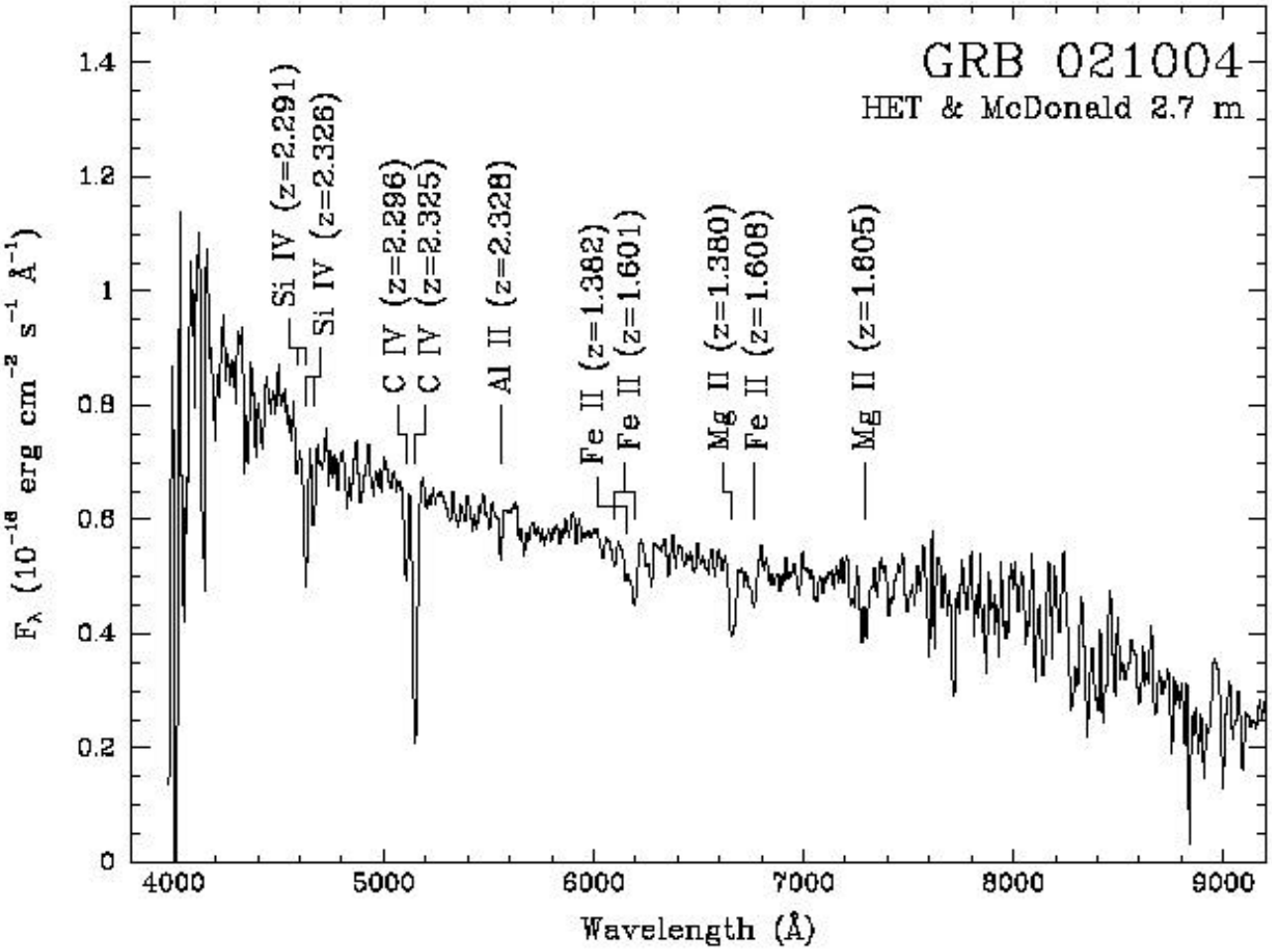
- GRB cosmology
- First Stars
- GRB observations by SWIFT



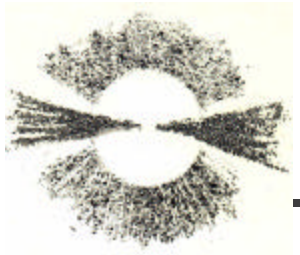


High precision radiography of ISM from z=2.3

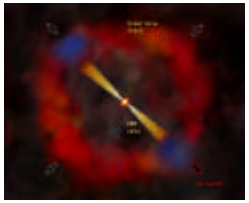


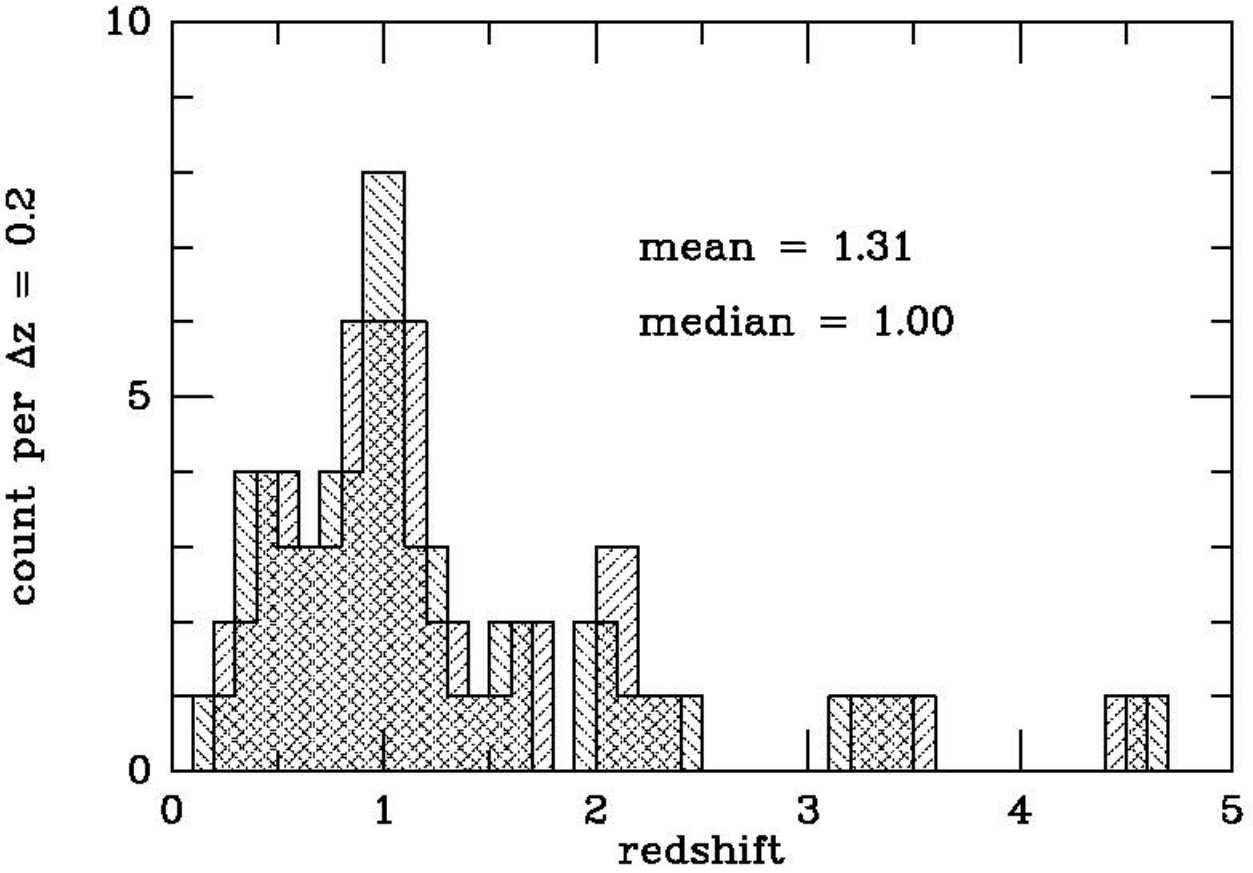


Schaefer et al. 2002



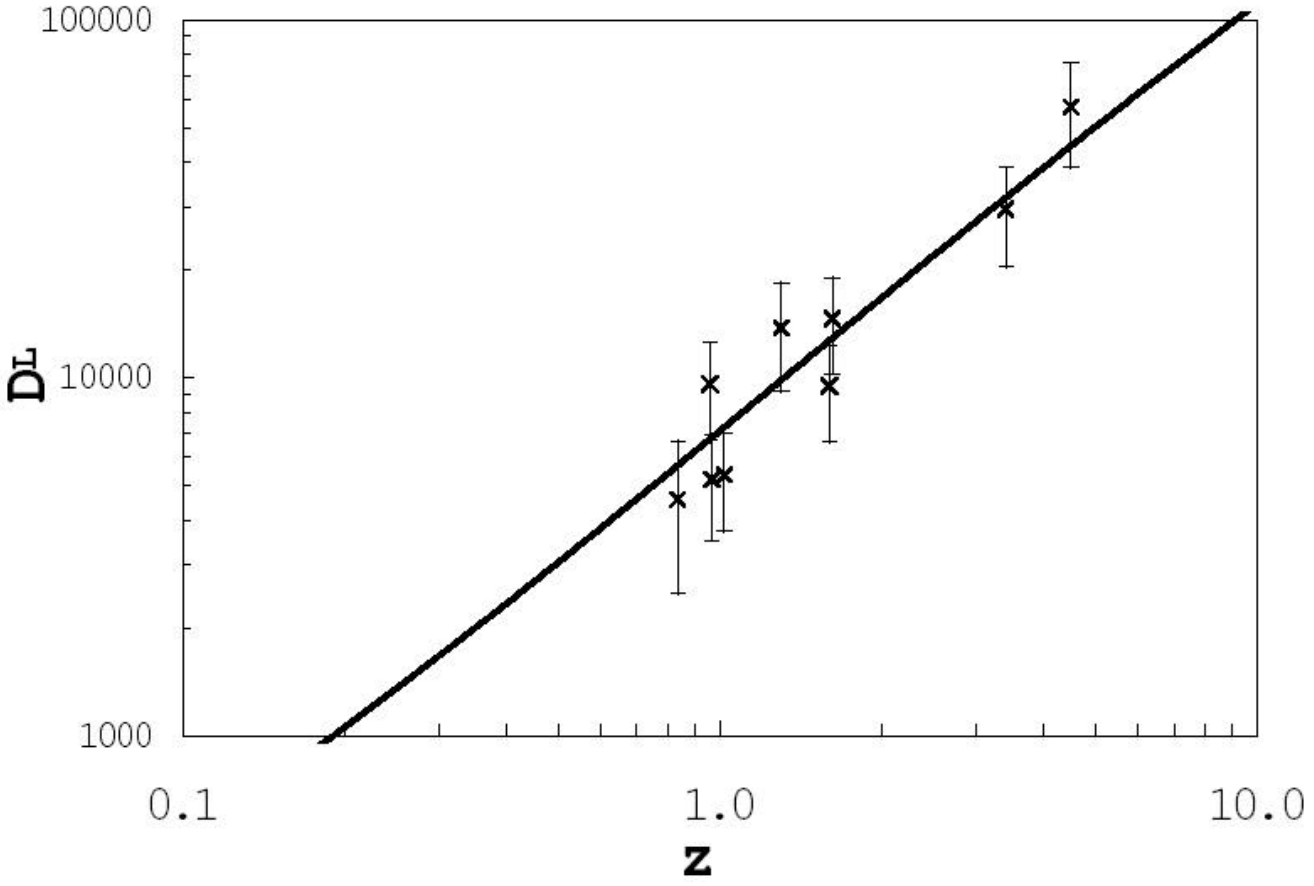
GRB and Cosmology



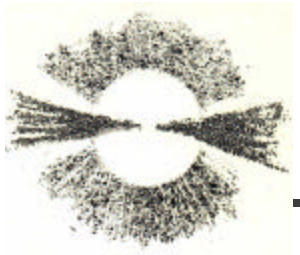


Djorgovski et al. 2003

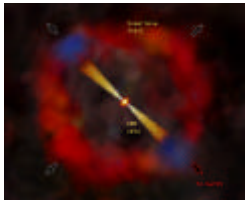
GRB and Cosmology



Schaefer (2003)



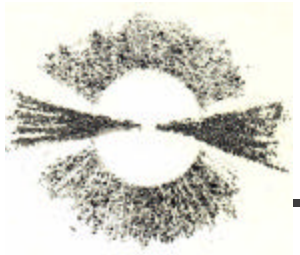
GRB and Cosmology



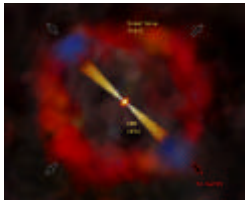
- Meszaros & Rees (2003) astro-ph/0305115
- GRB afterglow detection in the range (z = 10 – 30)

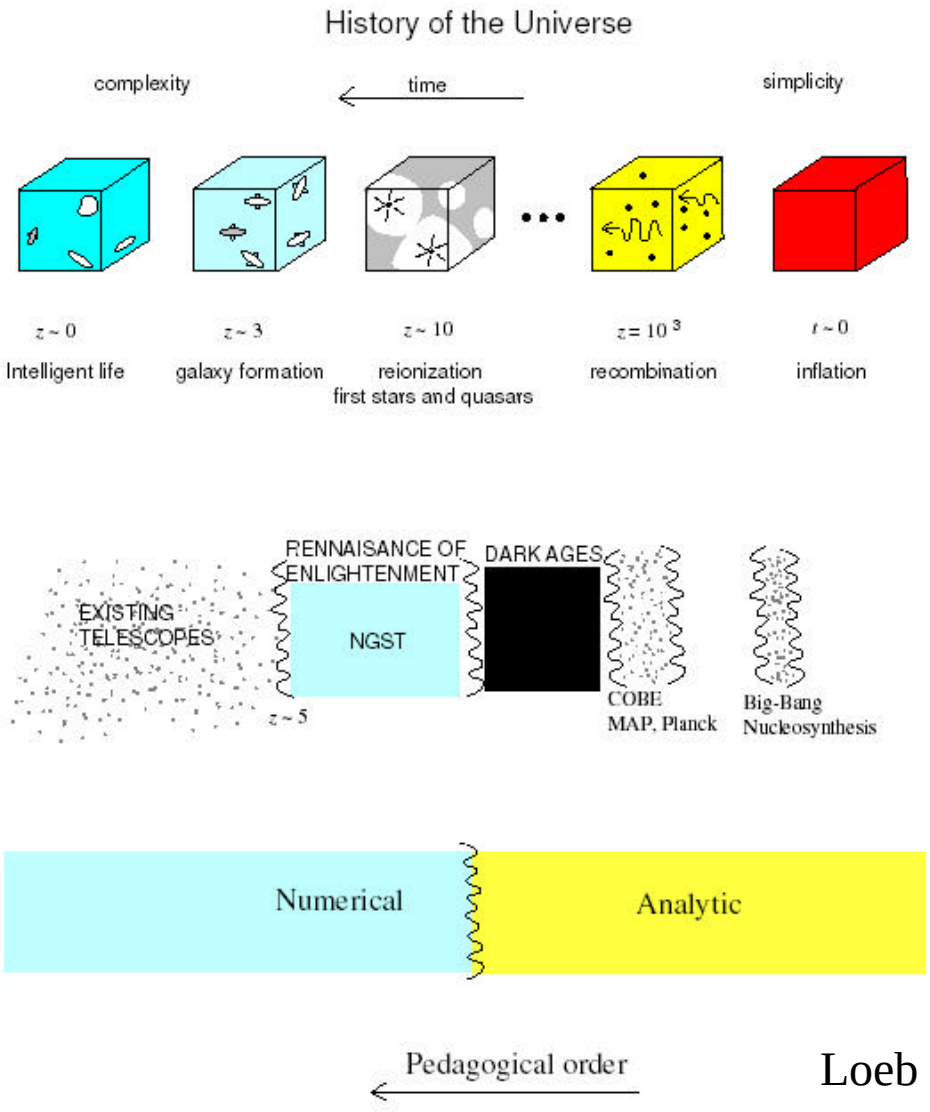
z	$\frac{\lambda_{\mathrm{Ly}\alpha,\mathrm{H}}}{\mu\mathrm{m}}$	$\frac{E_t}{\mathrm{keV}}$	$\frac{E_{Fe,\mathrm{K}\alpha}}{\mathrm{keV}}$	$F_E(10\mathrm{s})$	$F_E(10^2\mathrm{s})$	$F_E(10^3\mathrm{s})$	$F_E(10^4\mathrm{s})$	$F_E(10^5\mathrm{s})$
3	0.486	0.22	1.675	1.9^{-9}	6.8^{-10}	5.4^{-11}	4.3^{-12}	3.4^{-13}
6.5	0.912	0.22	0.893	6.1^{-10}	4.4^{-10}	3.5^{-11}	2.8^{-12}	2.2^{-13}
9.0	1.216	0.22	0.670	4.1^{-10}	4.1^{-10}	3.3^{-11}	2.6^{-12}	2.1^{-13}
12	1.581	0.22	0.515	3.0^{-10}	3.0^{-10}	3.2^{-11}	2.5^{-12}	2.0^{-13}
18	2.310	0.22	0.353	2.0^{-10}	2.0^{-10}	3.2^{-11}	2.6^{-12}	2.1^{-13}
30	3.770	0.22	0.216	1.3^{-10}	1.3^{-10}	3.5^{-11}	2.8^{-12}	2.2^{-13}

- X-ray flashes (E_{peak}, Rate ½ GRB, Isotropic) (Heise 2003) structured jets off-axis GRBs or high Z GRBs?

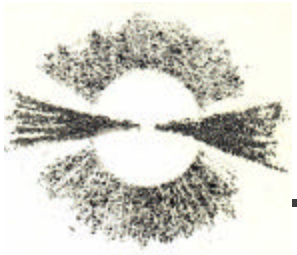


GRB Cosmology

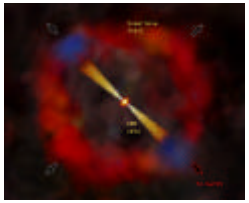




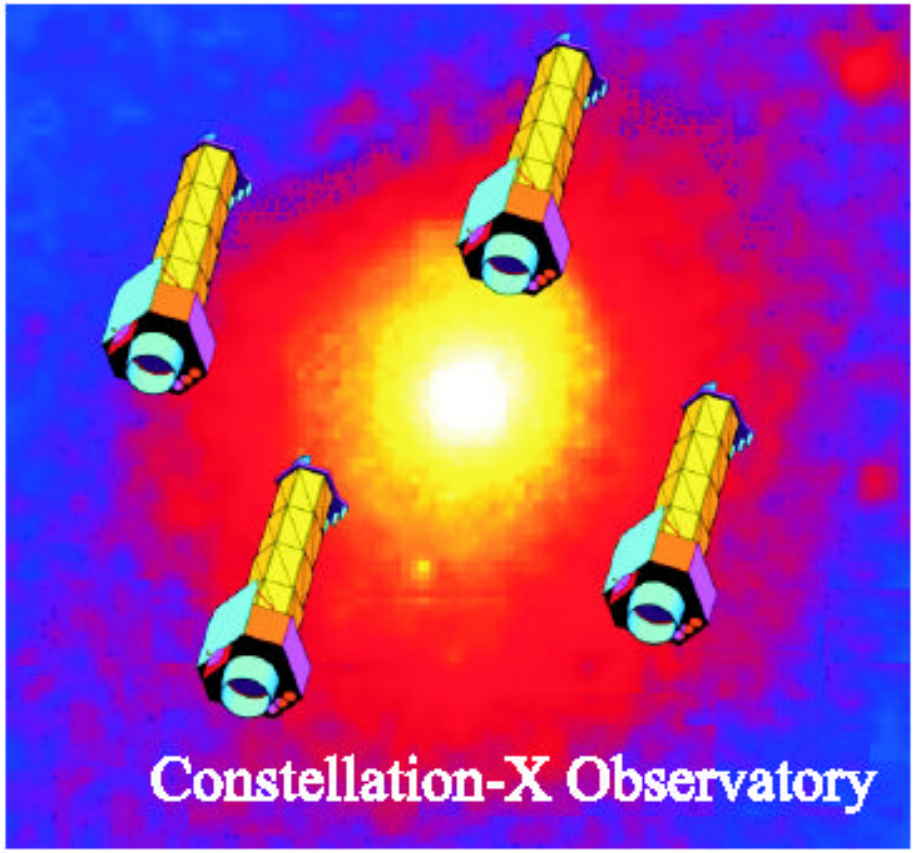
Loeb and Barkana (2000)

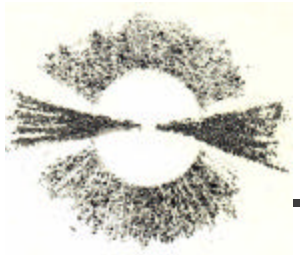


ConstellationX and GRB

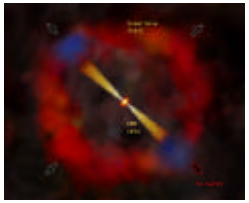


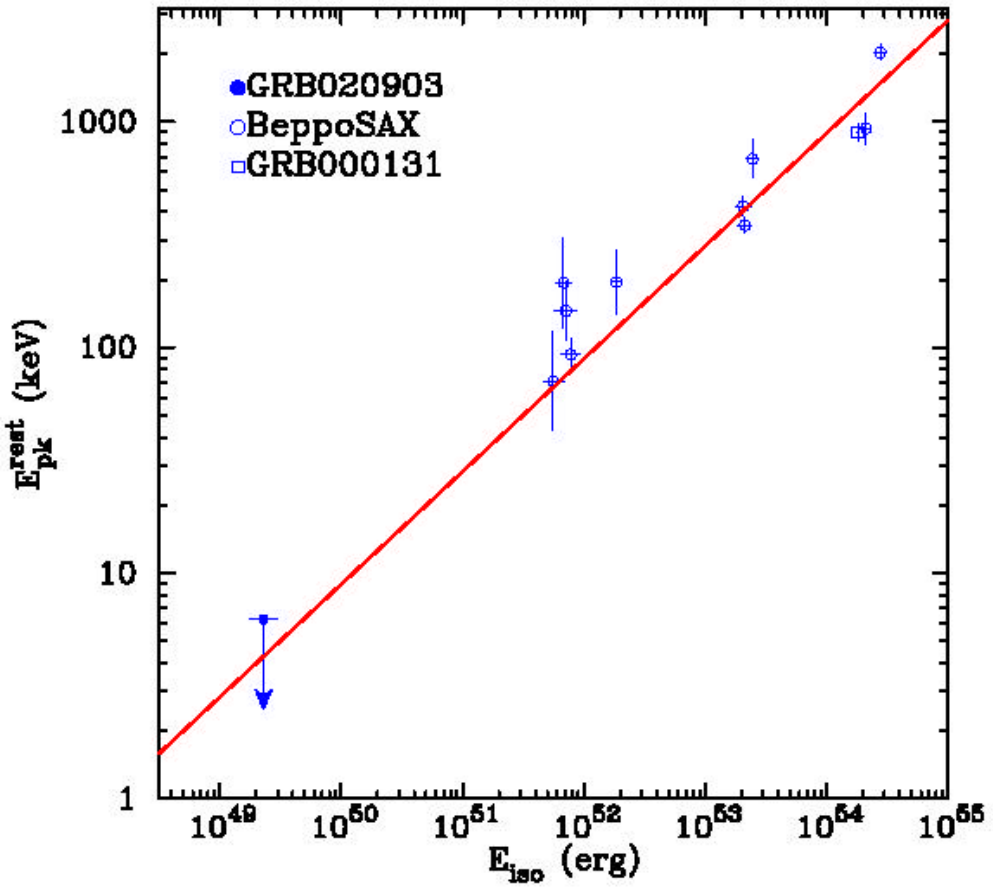
- Hints for detection
- Spectral measurement
- Other satellites



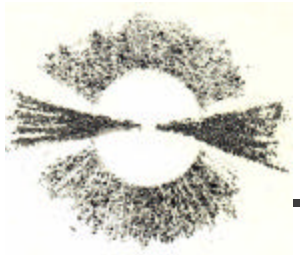


Peak Energy – Isotropic Energy

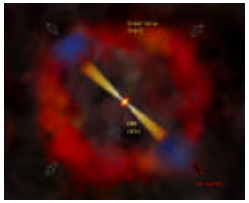


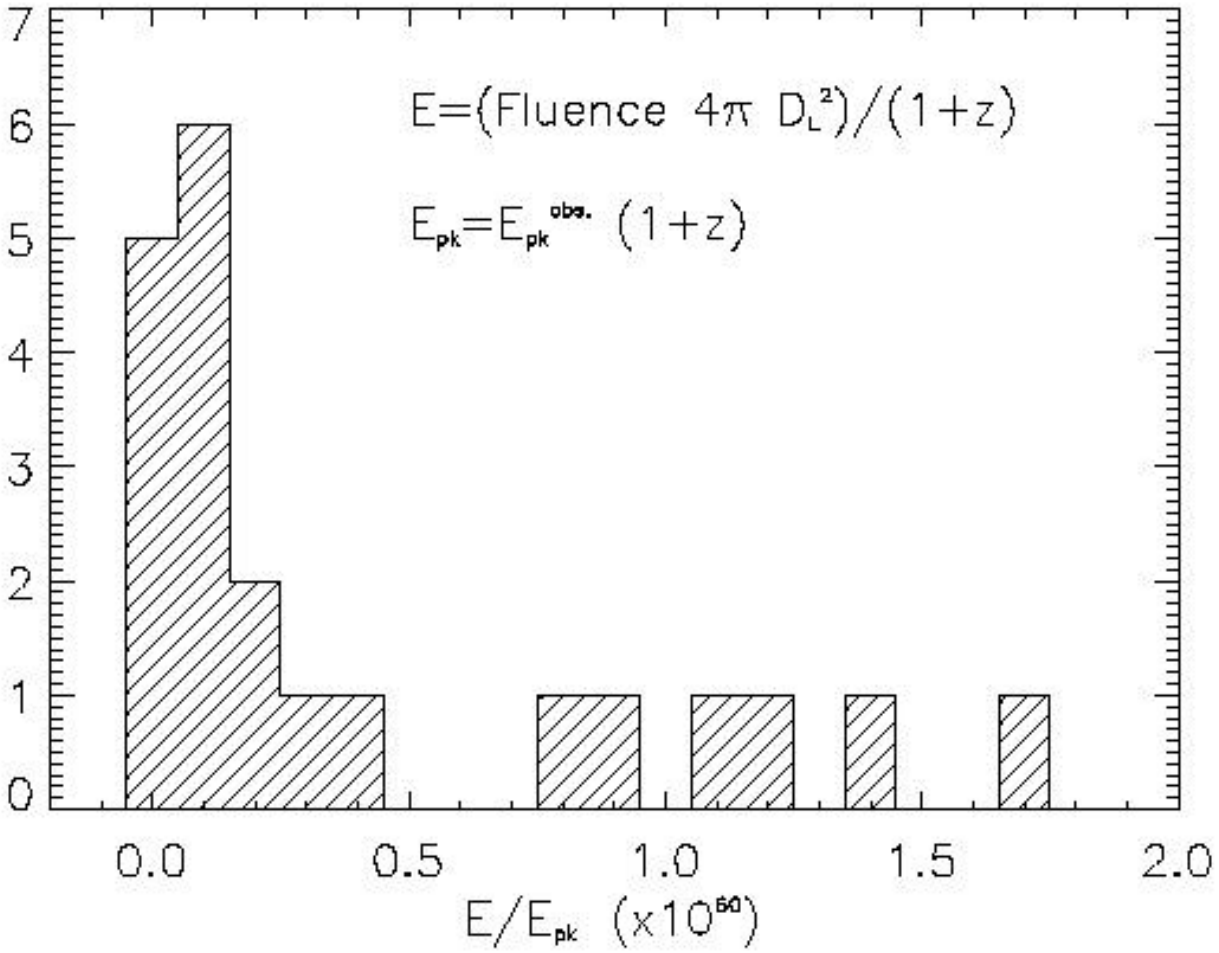


Sakamoto et al. (2003)

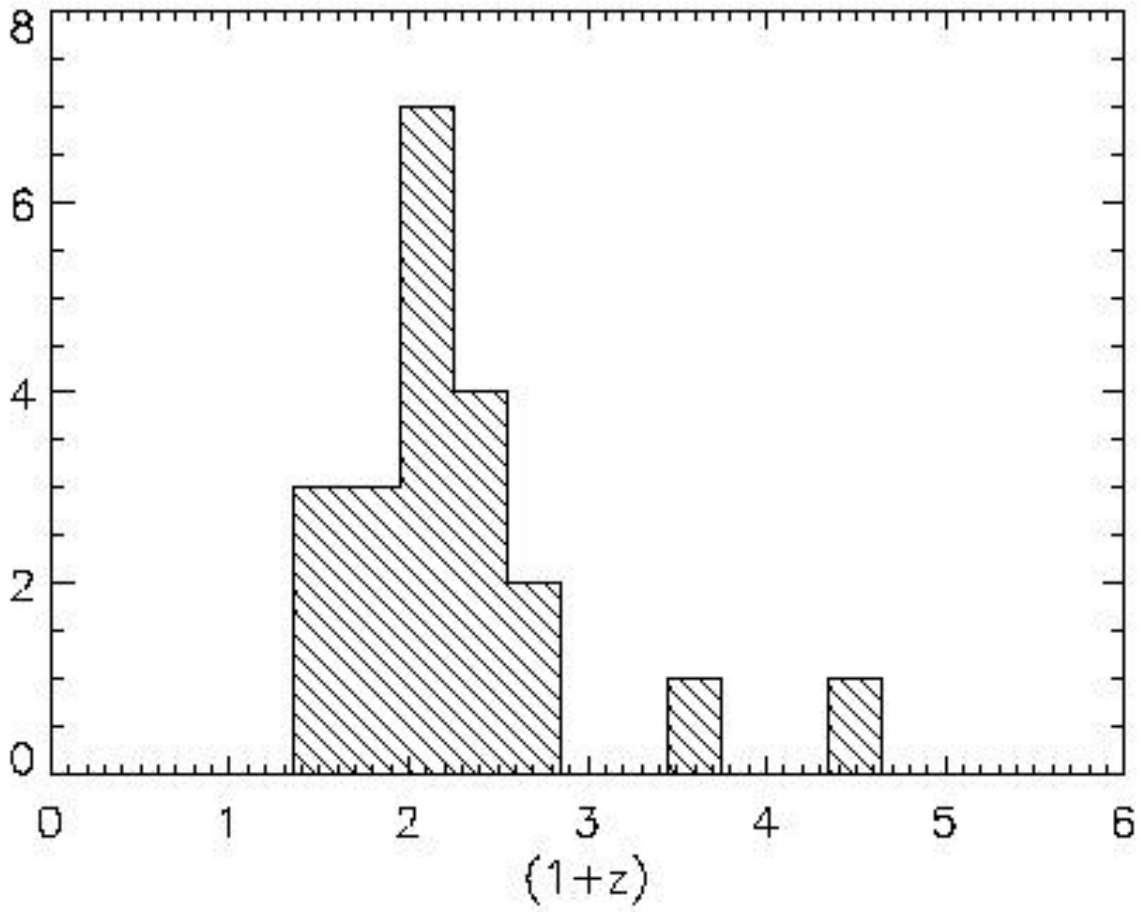


Peak Energy – Isotropic Energy

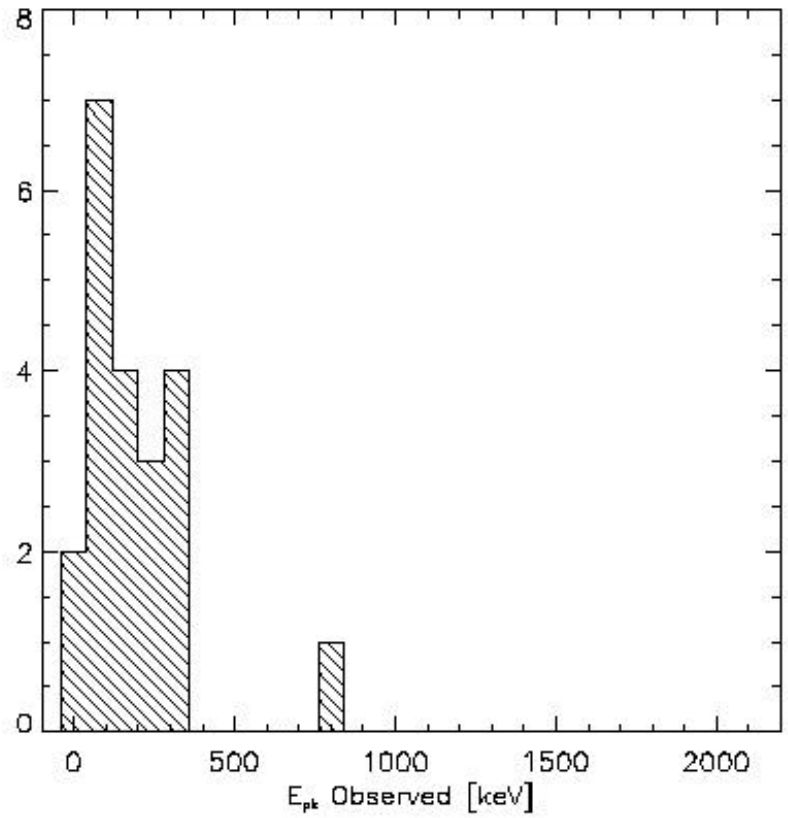


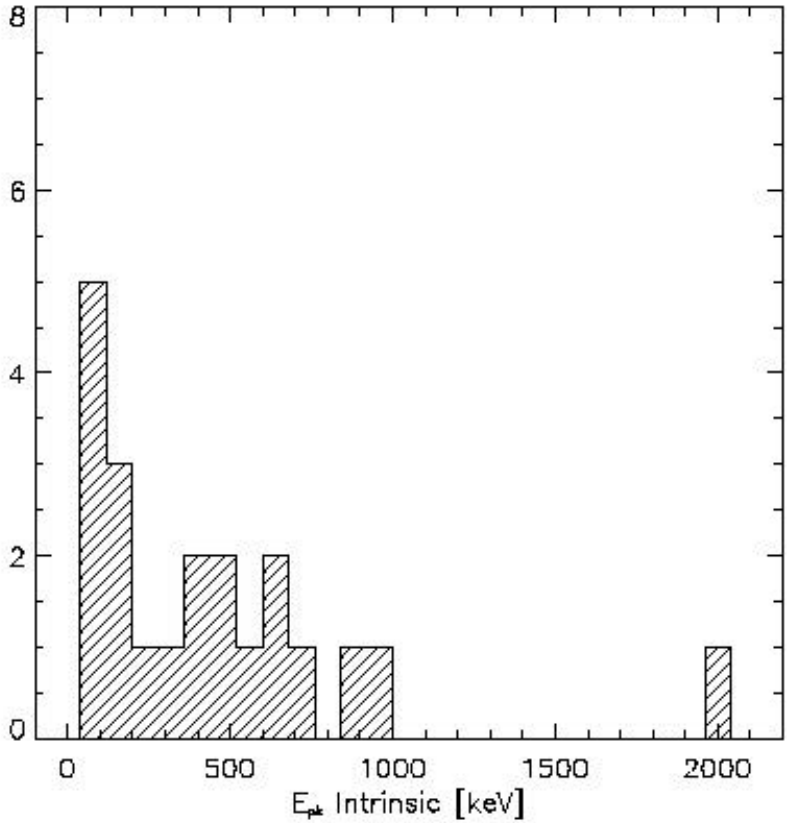


Redshift distribution

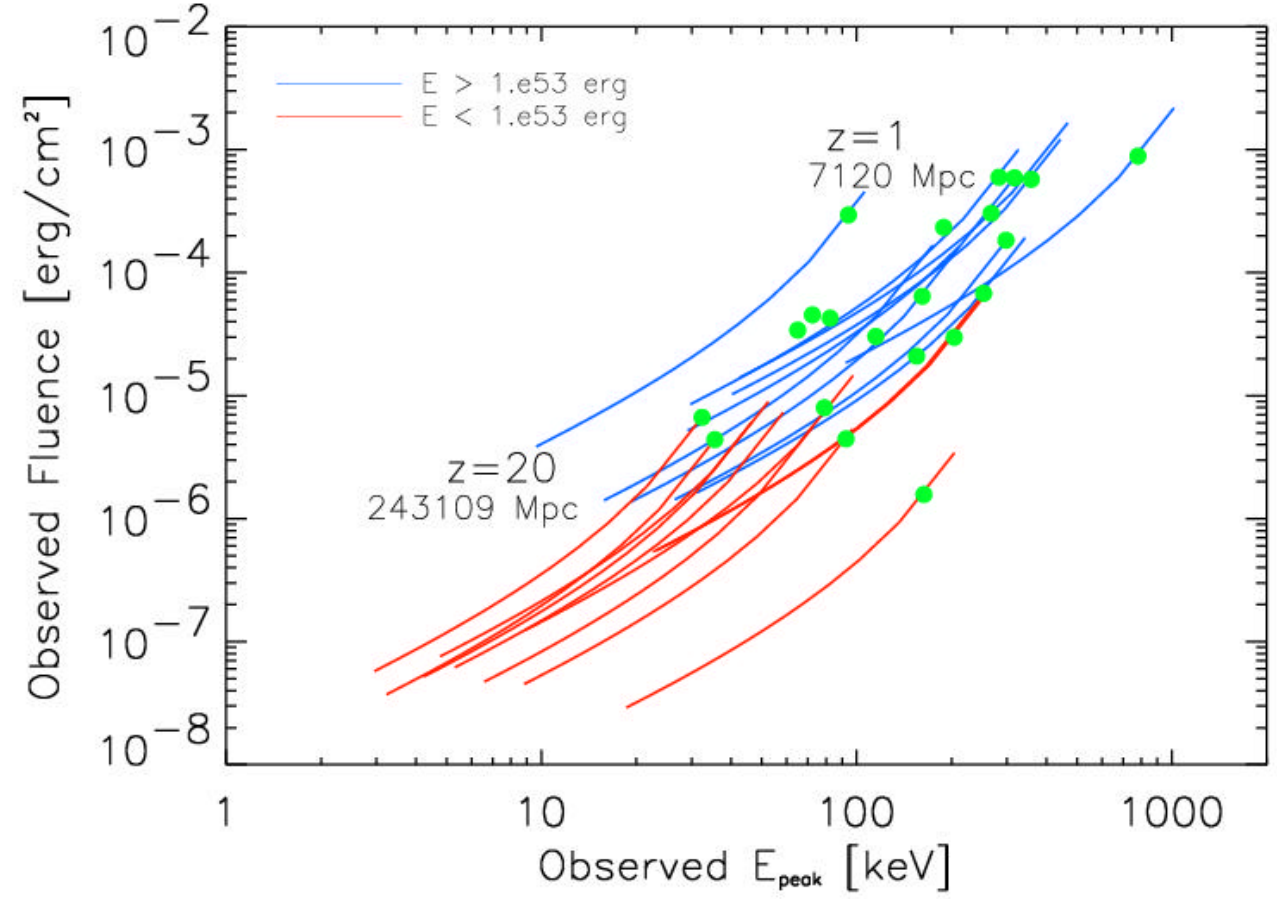


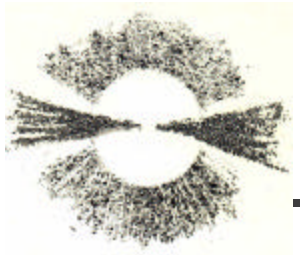
Peak Energy


8
6
4
2
0
0
500
1000
1500
2000
E_{pk} Observed [keV]

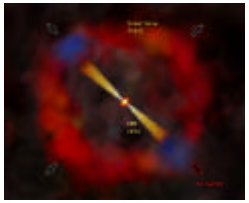

8
6
4
2
0
0
500
1000
1500
2000
E_{pk} Intrinsic [keV]

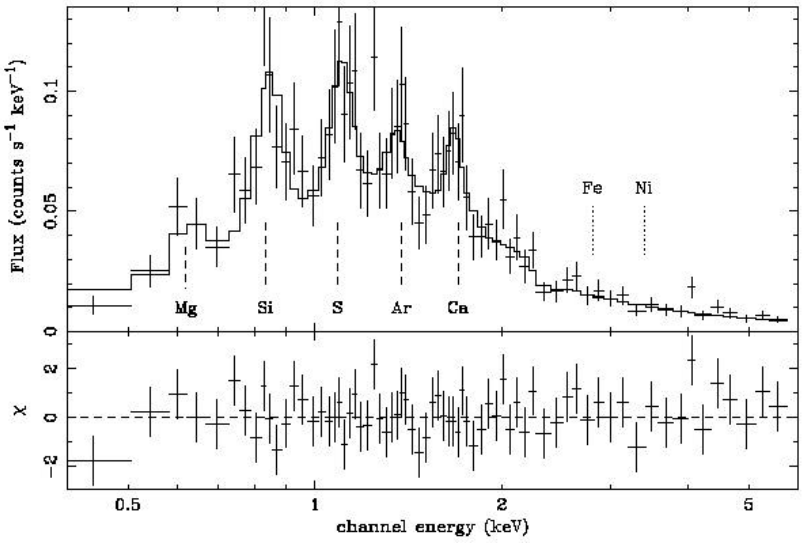
Peak Energy

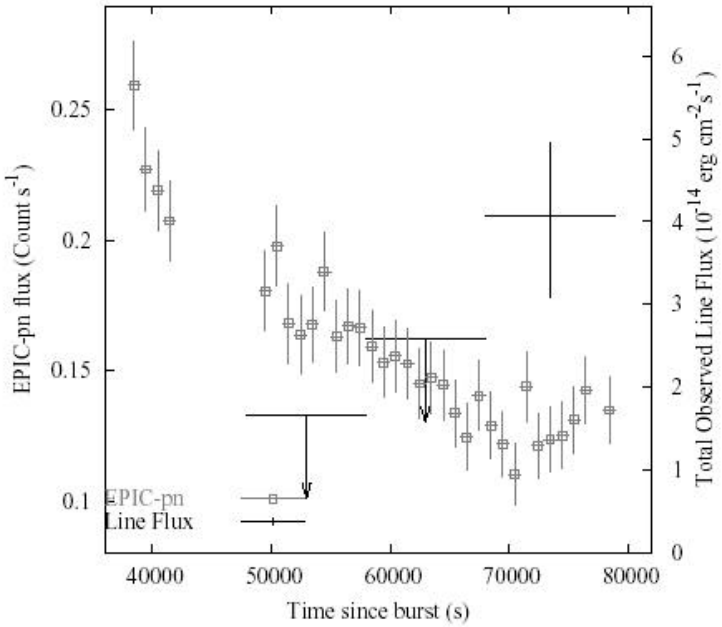

E > 1.e53 erg
E < 1.e53 erg
z=1
7120 Mpc
z=20
243109 Mpc
Observed Fluence [erg/cm²]
Observed E_peak [keV]
10^-2
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
1
10
100
1000



Spectral Measurements



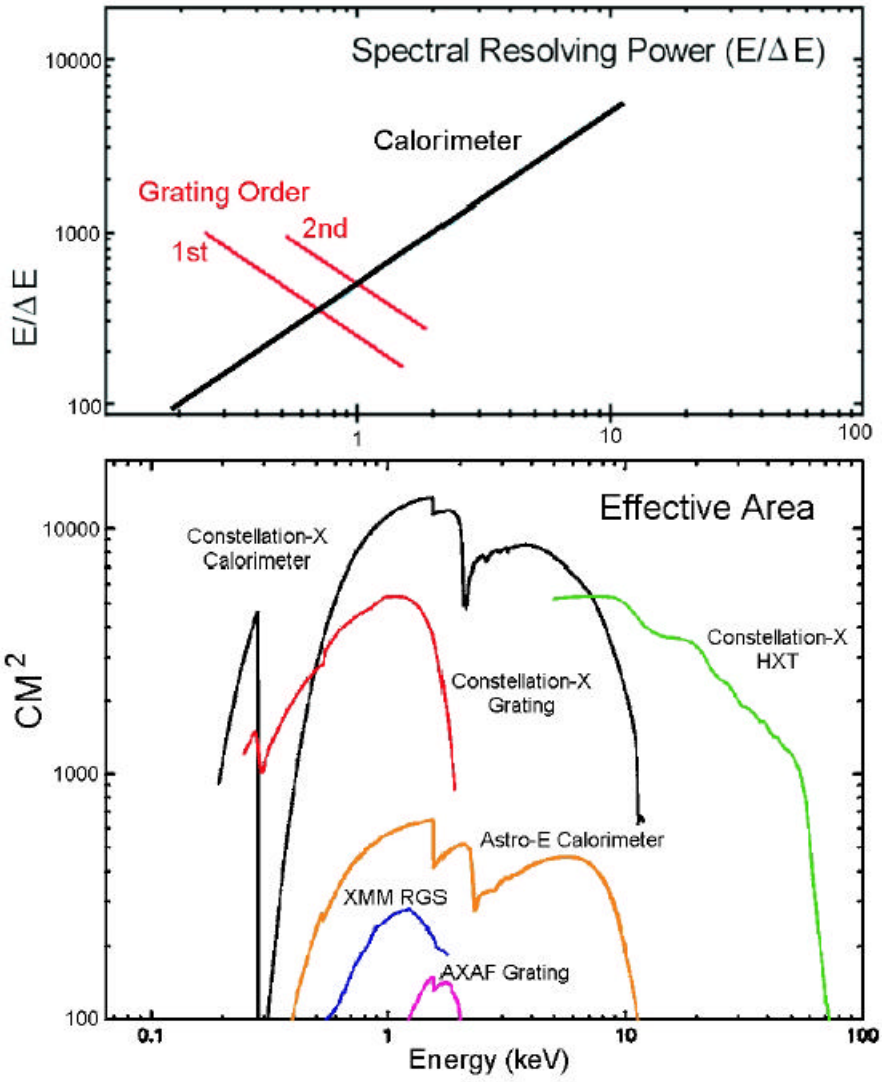


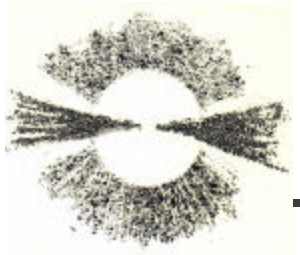


Line ID	Energy (keV)	Line z	Unabs. Flux (10^{-14} erg cm^{-2} s^{-1})	EW (eV)	Sig. %	σ
Mg XII	$0.62^{+0.03}_{-0.02}$	1.35	$9.1^{+7.9}_{-6.3}$	211^{+182}_{-146}	97	2.2
Si XIV	$0.86^{+0.02}_{-0.03}$	1.32	$4.1^{+2.7}_{-1.8}$	128^{+83}_{-57}	99.98	3.8
S XVI	$1.11^{+0.02}_{-0.02}$	1.34	$2.4^{+0.8}_{-1.0}$	93^{+33}_{-39}	99.96	3.5
Ar XVIII	$1.35^{+0.04}_{-0.03}$	1.44	$0.9^{+0.9}_{-0.6}$	43^{+42}_{-27}	92	1.7
(Ar XVIII)		(1.31)				
Ca XX	$1.66^{+0.04}_{-0.04}$	1.45	$1.3^{+0.6}_{-0.8}$	76^{+36}_{-44}	99	2.5
(Ca XIX)		(1.34)				

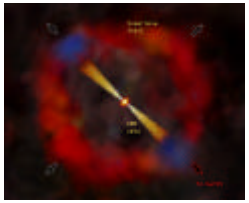
Matheson et al. (2003)

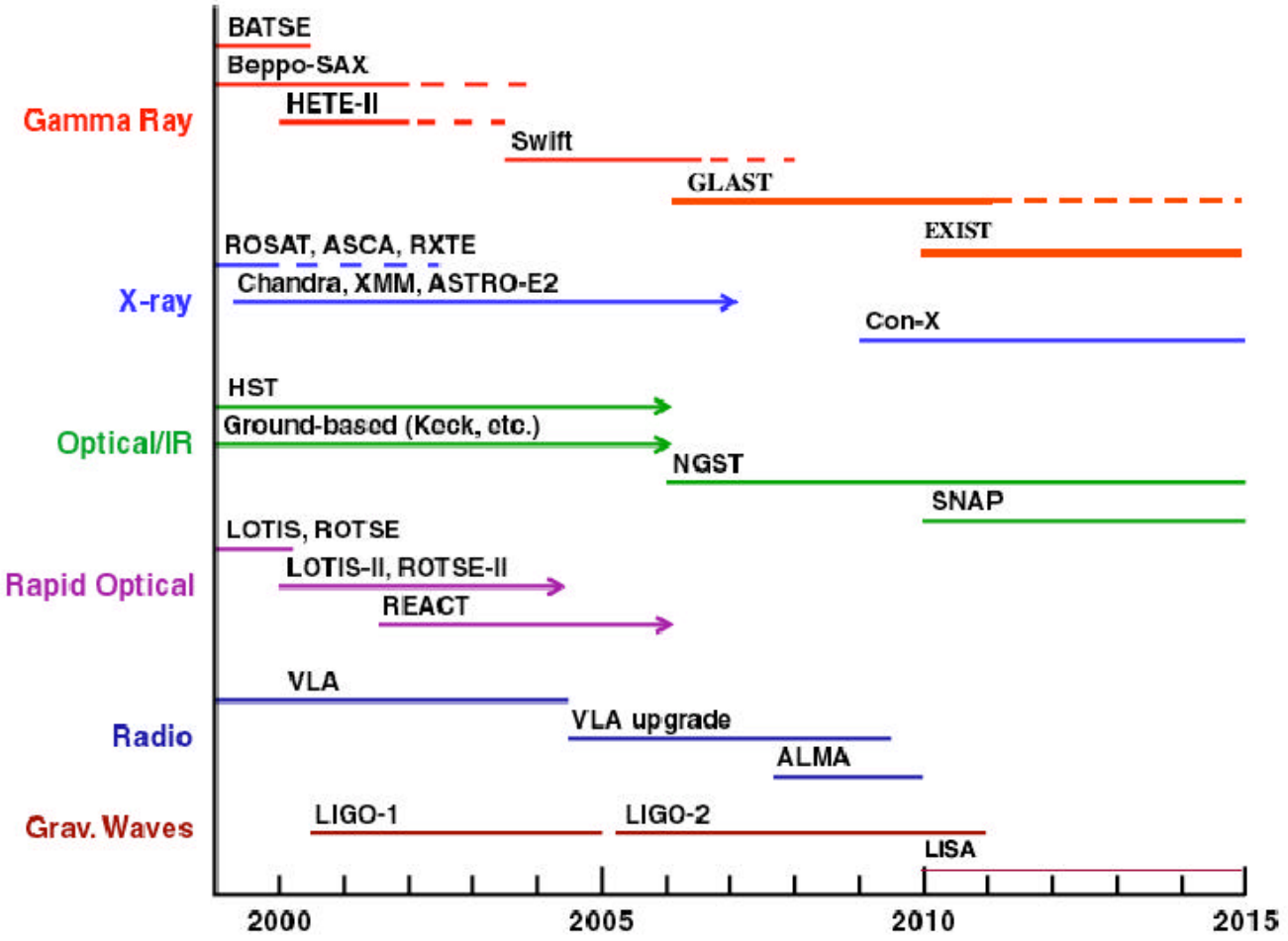
GRB and Constellation X



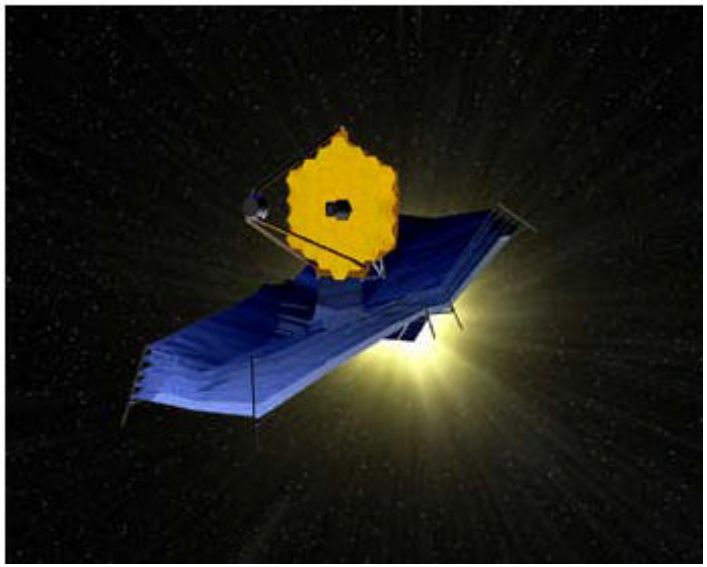


New Telescopes



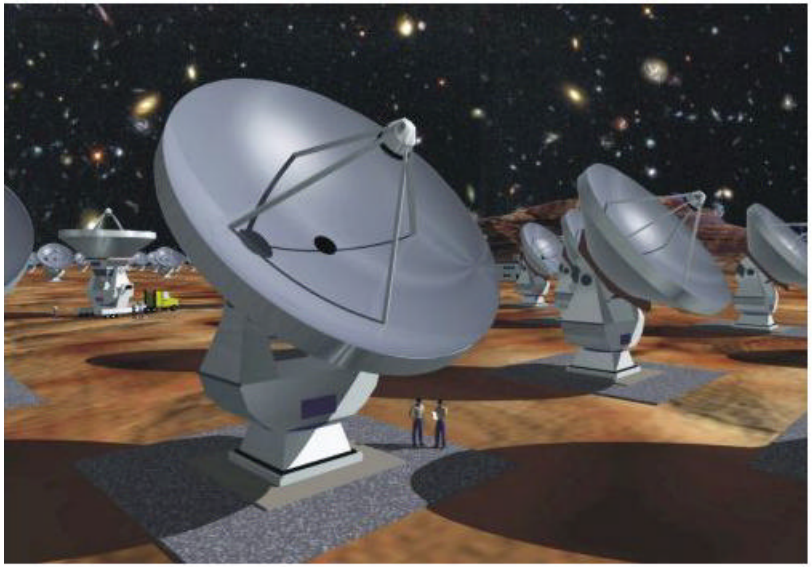


New Telescopes

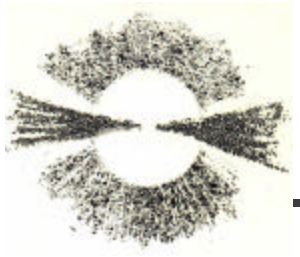


JWST

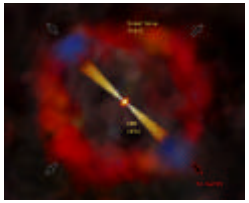
ALMA



EXIST



Conclusions



- GRB and Cosmology: a long story
- Study of first galaxies and first stars
- Look into the Dark Ages
- Spectroscopy of high-Z Universe
- GRB as standard candle?
- GRB as cosmological probe